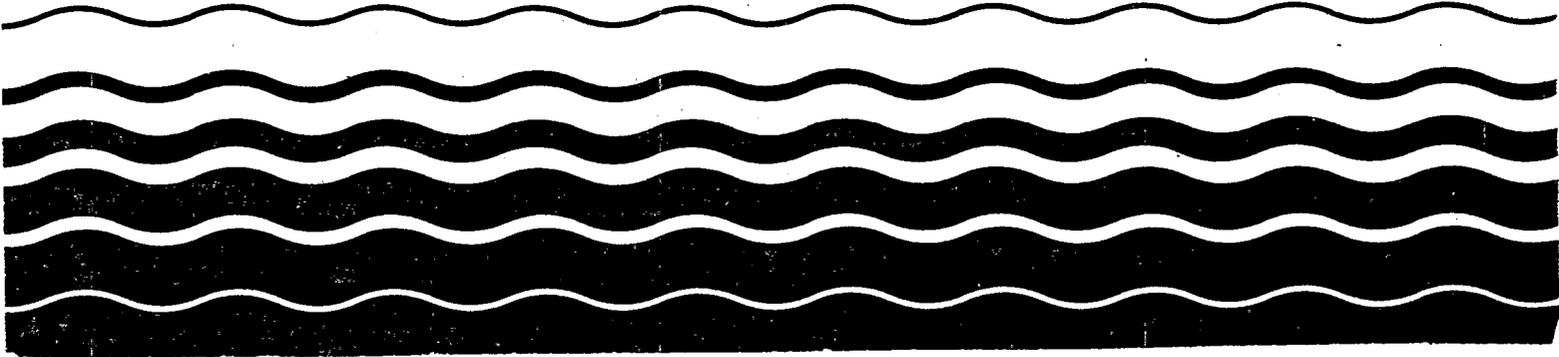


Water and Waste Management



Development **Draft**
Document for Proposed
Effluent Limitations
Guidelines and
Standards for the
Shipbuilding and Repair
Point Source Category

Reference



DEVELOPMENT DOCUMENT
FOR
PROPOSED BEST MANAGEMENT PRACTICES

for the

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DRYDOCKS
POINT SOURCE CATEGORY

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ABSTRACT

This document presents the findings of an extensive study of the shipbuilding and repair industry. Its purpose is to provide specific guidance for the development of discharge permits to be issued under the authority of Section 402 of the Federal Water Pollution Control Act as amended. These permits are issued by state and federal authorities participating in the National Pollutant Discharge Elimination System (NPDES).

The studies conducted by the Environmental Protection Agency (EPA) determined that the imposition of national industry-wide numerical limitations and standards is impractical at this time. This document, therefore, provides guidance which recommends specific best management practices. Such management practices should be tailored to specific facilities. This determination shall in no way restrict the use of numerical limitations in NPDES permits.

The best management practices identified in this document shall be guidance for the determination of best practicable control technology currently available, best available control technology economically achievable, and best available demonstrated control technology. Supporting data and rationale are contained in this document.

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SECTION I

CONCLUSIONS

An engineering evaluation of graving dock and floating drydock operations was conducted to determine potential for generation of pollutants from shipbuilding and repair operations. The practicability of establishing numerical effluent guidelines was evaluated. Current techniques employed by shipyards were evaluated with respect to practices which reduce constituent levels in discharges and with respect to variations in repair practices within the industry.

The conduct of the work involved contacts with thirty-eight shipyards, engineering visits with data collection in seven shipyards, and sampling during ship repair operations in two shipyards. Additionally, prior work conducted by the EPA, discharge data collected in response to NPDES discharge permit monitoring, and relevant literature prepared by the EPA, Navy, and private shipyards were evaluated.

This industry is such that numerical effluent limitations are impractical and difficult to apply in a manner which could be monitored; therefore, guidance is provided for controlling wastewater pollutant discharges which require that best management requirements be applied.

The quality of the water discharged from drydocks is highly dependent upon the process used for removal of paint, rust, and marine growths from the metal surfaces of ship hulls. These materials are found mixed in the spent blasting material. Rust and marine growth removed from the sides of the ship may increase quantities of solids in the waste stream.

Spent paint contains compounds of copper, zinc, chromium, tin and lead, as well as organotin compounds (References 5, 6, 8, and 15). Copper, Zinc, chromium, and lead have been identified as priority pollutants and as such, their discharge must be subject to control. The paint contributes to the solid load in the waste stream as well as coming in contact with stormwater, flooding waters, hosewater, and water spills. Additionally, it can be washed, pushed, or blown into uncovered drains or shore waters.

Antifouling paints are of particular concern. Toxic constituents, such as copper or organotin compounds are used in these paint formulations. Of special concern are the new organotin antifouling paints due to irritant and toxic effects of the paint.

The evaluation of literature, observations, and data leads to the following conclusions:

1. Segregation of water, except rainwater, from debris on drydock decks and removal of debris, spent paint and abrasive are the two most practical methods for reducing discharge of solids and wastewater.
2. Yards servicing freshwater vessels generally do not use abrasive blasting in preparing the hull for painting; therefore, some recommendations have been identified to be deleted for yards not using abrasive blasting.
3. Existing floating drydocks cannot be effectively monitored by normal sampling procedures because water drains from a rising dock through many scuppers, the ends, between pontoons, and through other openings.
4. On the basis of available sampling data, the type and the degree of activity occurring in the yards do not relate consistently to levels of pollutant constituents present in the wastewater.
5. Innovations such as closed-cycle blasting and vacuum equipment are currently in the development stage and show promise for increased productivity, reduction in airborne particulates, improved working conditions, and reduced abrasive blasting debris accumulations in drydocks.
6. Clean-up practices appear to enhance productivity by improving working conditions and allowing workers greater access to work areas.
7. Current regulations governing oil and grease spills are applicable to floating drydock and graving dock operations during flooding and deflooding.

The above conclusions are based upon data obtained during sampling at two facilities and similar data from other sources. Due to the nature of the facilities, sampling techniques are difficult to employ and estimates of the pollutant load had to take into account the processes occurring and the material balance. A complete material balance on the abrasive and spent blasting debris was considered and rejected because of inherent inaccuracies. Such factors as the unknown quantity of marine growth present on the hull, the unknown amount of paint to be removed, and uncontrollable introduction of rainwater and leakage into the abrasive blasting debris contribute to these inaccuracies. Further, dispersion of the material in the dock and possible inclusion of other forms of debris (for example, sediment and

marine organisms which enter during flooding and when the caissons are open) compound the problems associated with a material balance.

Shipyard practices strongly influence the amount of waste produced. Yards servicing only freshwater vessels produce no spent antifouling paints since antifoulants are not used on freshwater vessels. Freshwater vessels are rarely subjected to abrasive blasting and thus the spent primer paint and abrasive are not produced.

Shipyards servicing commercial oceangoing vessels remove paint, both antifouling and anticorrosive, to varying degrees depending on the desires of the vessel owner (Reference 5). Naval vessels are customarily stripped of paint to bare metal, whereas commercial vessels are stripped to bare metal only occasionally and more frequently only lightly sand blasted to prepare the surface to receive a coating of paint. Spent antifouling paint thus occurs in shipyards in different quantities.

Graving docks are subject to inflows of water which are not encountered with floating drydocks. Groundwater and gate leakage are the two major sources. Rainfall varies with climate but constitutes a third source. These inflows must be pumped from graving docks while rainfall can run off floating drydocks.

Leachability of spent paint is still an unresolved question. Primers containing lead oxide and zinc chromate do not appear to pose a leaching problem. Antifouling paints containing copper oxide may be leachable under some conditions, but factors such as amount of active material remaining, water pH, water temperature, water hardness, particle size, and contact time would appear to influence the amount of leaching if it occurs (References 5, 16, 17). Organotin paints may present hazards to workers during dry abrasive blasting. These paints are relatively new and little experience has been accumulated with them. Major unknowns with organotin paints are those of the extent of emission of tributyl-tin-oxide or tributyl-tin-fluoride (toxicants), the conversion of the organotin compounds to inorganic tin, and again, the actual leachability of the material. Formulations are prepared in differing concentrations depending upon the owners' specifications and the expected life of the protective coating.

Finally, it is concluded that a number of management practices are used at some yards which can be adapted to the needs of other yards. All facilities practice some degree of clean up at various times, although this may consist only of moving debris out of the work area when accumulations interfere with operations. During the docking period, some facilities use extensive clean-up procedures. In general drydock clean up is directed toward improving productivity and safety and toward maintaining acceptable working conditions. Both mechanical

and manual methods are in use. Control of water flows within the dock, like clean-up procedures, vary with each facility.

SECTION II

RECOMMENDATIONS

Based on the results of various studies, it is concluded that numerical effluent guidelines should not be established at this time because the nature of the discharge is not conducive to numerical monitoring.

On the basis of practices observed in and reported by various shipyards, Best Management Practices (BMP) have been developed for general application, and should be considered as guidance in lieu of numerical limitations. These are recommended for shipyard implementation by each individual facility in a manner best suited to the particular needs and conditions prevailing. The magnitude of the problem, equipment needed, physical drydock factors, scheduling, etc., should be considered in developing a plan to abate pollution.

The following specific requirements shall be incorporated in NPDES permits and are to be used as guidance in the development of a specific facility plan. Best Management Practices (BMP) numbered 2, 5, 7 and 10 should be considered on a case-by-case basis for yards in which wet blasting to remove paint or dry abrasive blasting do not occur, and BMP 10 does not apply to floating drydocks.

BEST MANAGEMENT PRACTICES (BMP)

- BMP 1. Control of Large Solid Materials. Scrap metal, wood and plastic, miscellaneous trash such as paper and glass, industrial scrap and waste such as insulation, welding rods, packaging, etc., shall be removed from the drydock floor prior to flooding or sinking.
- BMP 2. Control of Blasting Debris. Clean-up of spent paint and abrasive shall be undertaken as part of the repair or production activities to the degree technically feasible to prevent its entry into drainage systems. Mechanical clean-up may be accomplished by mechanical sweepers, front loaders, or innovative equipment. Manual methods include the use of shovels and brooms. Innovations and procedures which improve the effectiveness of clean-up operations shall be adapted, where they can be demonstrated as preventing the discharge of solids. Those portions of the drydock floor which are reasonably accessible shall be "scraped or broomed clean" (see Glossary) of spent abrasive prior to flooding.

After a vessel has been removed from the drydock and the dock has been deflooded for repositioning of the keel and

bilge blocks, the remaining areas of the floor which were previously inaccessible shall be cleaned by scraping or broom cleaning prior to the introduction of another vessel into the drydock. The requirement to clean the previously inaccessible area shall be waived either in an emergency situations or when another vessel is ready to be introduced into the drydock within fifteen (15) hours. Where tides are not a factor, this time shall be eight (8) hours.

BMP 3. Oil, Grease, and Fuel Spills. During the drydocked period oil, grease, or fuel spills shall be prevented from reaching drainage systems and from discharge with drainage water. Cleanup shall be carried out promptly after an oil or grease spill is detected.

BMP 4. Paint and Solvent Spills. Paint and solvent spills shall be treated as oil spills and segregated from discharge water. Spills shall be contained until clean-up is complete. Mixing of paint shall be carried out in locations and under conditions such that spills shall be prevented from entering drainage systems and discharging with the drainage water.

BMP 5. Abrasive Blasting Debris (Graving Docks). Abrasive blasting debris in graving docks shall be prevented from discharge with drainage water. Such blasting debris as deposits in drainage channels shall be removed promptly and as completely as is feasible. In some cases, covers can be placed over drainage channels, trenches, and other drains in graving docks to prevent entry of abrasive blasting debris.

The various process wastewater streams shall be segregated from sanitary wastes. Gate and hydrostatic leakage may also require segregation.

BMP 6. Segregation of Waste Water Flows in Drydocks. The various process wastewater streams shall be segregated from sanitary wastes. Gate and hydrostatic leakage may also require segregation.

BMP 7. Contact Between Water and Debris. Shipboard cooling and process water shall be directed so as to minimize contact with spent abrasive and paint and other debris. Contact of spent abrasive and paint by water can be reduced by proper segregation and control of wastewater streams. When debris is present, hosing of the dock should be minimized. When hosing is used as a removal method, appropriate methods should be incorporated to prevent accumulation of debris in drainage systems and to promptly remove it from such systems to prevent its discharge with wastewater.

- BMP 8. Maintenance of Gate Seals and Closure. Leakage through the gate shall be minimized by repair and maintenance of the sealing surfaces and proper seating of the gate. Appropriate channelling of leakage water to the drainage system should be accomplished in a manner that reduces contact with debris.
- BMP 9. Maintenance of Hoses, Soil Chutes, and Piping. Leaking connections, valves, pipes, hoses, and soil chutes carrying either water or wastewater shall be replaced or repaired immediately. Soil chute and hose connections to the vessel and to receiving lines or containers shall be positive and as leak free as practicable.
- BMP 10. Water Blasting, Hydroblasting, and Water-Cone Abrasive Blasting (Graving Docks). When water blasting, hydroblasting, or water-cone blasting is used in graving docks to remove paint from surfaces, the resulting water and debris shall be collected in a sump or other suitable device. This mixture then will be either delivered to appropriate containers for removal and disposal or subjected to treatment to concentrate the solids for proper disposal and prepare the water for reuse or discharge.

SECTION III

INDUSTRY CHARACTERIZATION

Shipbuilding and repair operations have been identified by EPA as a division of the ship construction industry requiring consideration of point source discharges which may require effluent limitation guidelines. Specifically, graving docks and floating drydocks were evaluated with respect to the potential contamination of receiving waters by wastes generated by ship repair and discharged during flooding of graving docks, immersion of floating drydocks, or with drainage water and runoff.

An engineering evaluation of graving dock and floating drydock operations was conducted to determine potential for generation of wastes from shipbuilding and repair operations in graving and floating drydocks. The practicality of establishing numerical effluent limitation guidelines was evaluated for drydocks. The evaluation was accomplished by:

- o Literature Research
- o Contacting and visiting shipyards
- o Observing ship repair operations and the applications of methods designed to reduce or eliminate pollutational constituents in effluents
- o Sampling and analyzing discharge constituents
- o Determining the feasibility of monitoring and sampling of waste discharges from graving docks and floating drydocks
- o Evaluating the technology being utilized to treat or control pollutant discharges, and determining what applicable technology may be applied to minimize the discharge of pollutants to receiving waters

There are eighty-four shipyards in the United States that utilize graving and floating drydocks. Among the shipyards are sixty-eight graving docks and 151 floating drydocks. In the conduct of the work, thirty-eight shipyards were contacted on the Atlantic Coast, Gulf Coast, Great Lakes and Inland Waterways, and Pacific Coast to determine which of the major shipyards are involved in minimizing pollutant discharges by utilizing specific control methods. Seven shipyards, referred to in the text by letters A through G, were visited to observe operations and record data. Samples were taken from the discharges from graving docks of two of these seven

shipyards, shipyards B and D. The samples were analyzed and the constituent levels were evaluated with respect to the ship repair operations being performed and the discharge control methods utilized. The analyses were combined with other engineering data to establish the degree of pollutant discharges, to define the nature of discharges from ship repair operations, and to recommend effluent limitation guidelines if practicable or alternatives to guidelines if necessary.

BACKGROUND - The Clean Water Act

The Federal Water Pollution Control Act Amendments of 1972 established a comprehensive program to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters." Section 101(a). By July 1, 1977, existing industrial dischargers were required to achieve "effluent limitations requiring the application of the best practicable control technology currently available" ("BPT"), Section 301(b)(1)(A); and by July 1, 1983, these dischargers were required to achieve "effluent limitations requiring the application of the best available technology economically achievable ... which will result in reasonable further progress toward the national goal of eliminating the discharge of all pollutants" ("BAT"), Section 301(b)(2)(A). New industrial direct dischargers were required to comply with Section 306 new source performance standards ("NSPS"), based on best available demonstrated technology; and new and existing dischargers to publicly owned treatment works ("POTWs") were subject to pretreatment standards under Sections 307(b) and (c) of the Act. While the requirements for direct dischargers were to be incorporated into National Pollutant Discharge Elimination System (NPDES) permits issued under Section 402 of the Act, pretreatment standards were made enforceable directly against dischargers to POTWs (indirect dischargers).

Although Section 402(a)(1) of the 1972 Act authorized the setting of requirements for direct dischargers on a case-by-case basis, Congress intended that, for the most part, control requirements would be based on regulations promulgated by the Administrator of EPA. Section 304(b) of the Act required the Administrator to promulgate regulations providing guidelines for effluent limitations setting forth the degree of effluent reduction attainable through the application of BPT and BAT. Moreover, Sections 304(c) and 306 of the Act required promulgation of regulations for NSPS, and Sections 304(f), 307(b), and 307(c) required promulgation of regulations for pretreatment standards. In addition to these regulations for designated industry categories, Section 307(a) of the Act required the Administrator to promulgate effluent standards applicable to all dischargers of toxic pollutants. Finally, Section 501(a) of the Act authorized the Administrator to prescribe any additional regulations "necessary to carry out his functions" under the Act.

EPA was unable to promulgate many of these regulations by the dates contained in the Act. In 1976, EPA was sued by several environmental groups, and in settlement of this lawsuit EPA and the plaintiffs executed a "Settlement Agreement", which was approved by the Court. This Agreement required EPA to develop a program and adhere to a schedule for promulgating for 21 major industries BAT effluent limitations guidelines, pretreatment standards, and new source performance standards for 65 "priority" pollutants and classes of pollutants. See Natural Resources Defense Council, Inc. v. Train, 8 ERC 2120 (D.D.C. 1976), modified March 9, 1979.

On December 27, 1977, the President signed into law the Clean Water Act of 1977. Although this law makes several important changes in the Federal water pollution control program, its most significant feature is its incorporation into the Act of several of the basic elements of the Settlement Agreement program for toxic pollution control. Sections 301(b) (2) (A) and 301(b) (2) (C) of the Act now require the achievement by July 1, 1984, of effluent limitations requiring application of BAT for "toxic" pollutants, including the 65 "priority" pollutants and classes of pollutants which Congress declared "toxic" under Section 307(a) of the Act. Likewise, EPA's programs for new source performance standards and pretreatment standards are now aimed principally at toxic pollutant controls. Moreover, to strengthen the toxics control program, Congress added Section 304(e) to the Act, authorizing the Administrator to prescribe "best management practices" ("BMPs") to prevent the release of toxic and hazardous pollutants from plant site runoff, spillage or leaks, sludge or waste disposal, and drainage from raw material storage associated with, or ancillary to, the manufacturing or treatment process.

In keeping with its emphasis on toxic pollutants, the Clean Water Act of 1977 also revised the control program for non-toxic pollutants. Instead of BAT for "conventional" pollutants identified under Section 304(a) (4) (including biological oxygen demand, suspended solids, fecal coliform and pH), the new Section 301(b) (2) (E) requires achievement by July 1, 1984, of "effluent limitations requiring the application of the best conventional pollutant control technology" ("BCT"). The factors considered in assessing BCT for an industry include the costs of attaining a reduction in effluents and the effluent reduction benefits derived compared to the costs and effluent reduction benefits from the discharge of publicly owned treatment works (Section 304(b) (4) (B)). For non-toxic, nonconventional pollutants, Sections 301(b) (2) (A) and (b) (2) (F) require achievement of BAT effluent limitations within three years after their establishment or July 1, 1984, whichever is later, but not later than July 1, 1987.

SUMMARY OF METHODS USED FOR DETERMINING THE PRACTICALITY OF EFFLUENT LIMITATIONS GUIDELINES AND STANDARDS OF PERFORMANCE

The recommendations and standards of performance proposed herein have been developed in the following manner.

Industry and Waste Load Categorization

The industry was first studied to determine whether or not separate limitations and standards would be required for different divisions within the category. Factors considered included the nature of the physical facilities involved, the types of activities performed, processes within each activity, and materials used.

Raw waste characteristics were then identified. This included analyses of (1) the sources and volumes of water required in each process, (2) non-process related sources of wastes and wastewaters, and (3) the components potentially present in wastewaters.

Wastewaters originating from the vessel in drydock included sanitary wastes and cooling water. (Sanitary wastes are not included in the scope of this document). Dock originating wastewaters were identified as gate and dock leakage, rainfall, water from occasional wet blasting operations, and water used in flooding the drydock for docking and undocking of the vessels.

The major concern with respect to potential pollution problems was identified as spent paint and abrasive blasting material. Hull cleaning practices were found to vary within each yard contacted, and the magnitude of this potential problem likewise varies.

Recommendations for reducing or eliminating potential environmental hazards have been based upon information obtained in the course of this effort, prior work performed by other organizations, and literature available as reference material.

Treatment and Control Technologies

The range of control and treatment technologies within the industry was identified. Included were both treatment technology and operating practices. Applicability and reliability of each treatment and control technology were investigated, as was the required time for implementation. In addition, environmental impacts of such technologies upon other pollution problems, such as air and solid waste, were identified.

Data Base

Engineering data was obtained from a number of sources including EPA and U.S. Navy research information, EPA, Navy and State environmental personnel, trade associations, published literature, qualified technical consultations, and historical information on effluent quality and quantity. In addition, on-site engineering visits and analytical programs were conducted at specific shipyards and other shipyards were contacted for information. Table III-1 describes the extent of this shipyard information acquisition program. NPDES permits and water pollution control plans for these facilities were reviewed. Results of monitoring required under the permits were of value when samples were taken at outfalls directly related to drydock operation.

Table III-1

SUMMARY OF SHIPYARD INFORMATION ACQUISITION PROGRAM

| <u>Category</u> | <u>Total in Category No. of Docks (No. of Shipyards)</u> | <u>Contacted No. of Docks (No. of Shipyards)</u> | <u>Visited No. of Docks (No. of Shipyards)</u> |
|--------------------------|--|--|--|
| Graving Docks | | | |
| East Coast | 39 (14) | 15 (6) | 5 (2) |
| Great Lakes | 8 (5) | 8 (5) | 2 (1) |
| Gulf Coast | 3 (3) | 0 (0) | 0 (0) |
| West Coast | 18 (5) | 12 (4) | 4 (2) |
| Total | 68 (27) | 35 (15) | 11 (5) |
| Floating Drydocks | | | |
| East Coast | 58 (21) | 29 (8) | 3 (1) |
| Great Lakes | 7 (3) | 7 (3) | 0 (0) |
| Gulf Coast | 36 (21) | 13 (6) | 2 (1) |
| West Coast | 50 (23) | 30 (11) | 4 (2) |
| Total | 151 (68) | 79 (28) | 9 (4) |

Previous work has been performed by others in an effort to characterize and limit discharges from shipyard activities. One such study by Hamilton Standard Division of United Technologies, Inc., recommended clean-up techniques rather than effluent limitations (Reference 1).

Other studies have been performed in an effort to facilitate issuance of NPDES permits. The EPA Office of Enforcement, Denver, Colorado conducted studies of San Diego and Newport News harbors. On the basis of its findings, housekeeping measures were recommended, primarily to prevent contact between water and spent abrasive and paint blasted from the vessels (Reference 2).

Various leaching studies have been performed to determine whether or not spent paint and abrasive are leachable. Section V discusses the results of these studies. These previous efforts have been considered in the current work.

Cost information was obtained directly from industry during shipyard visits, from engineering firms, equipment suppliers, and from the literature. These costs have been used to develop general capital, operating, and total costs for each treatment and control method. This generalized cost data was used to estimate the costs of Best Management Practices in Section VIII.

Selection of Facilities

From the total population of drydocking facilities thirty-eight were contacted by telephone to obtain information on practices and operations, seven were visited by project personnel, and of the latter group two were selected for sampling of wastewater during operations.

Shipyards contacted by telephone were located in all geographic areas of the continental United States. Visits were conducted to yards located on the East, West, and Gulf Coasts, and on the Great Lakes. Sampling was conducted on the East and West Coasts.

GENERAL DESCRIPTION OF INDUSTRY

Activities Carried Out At Shipyard Facilities

The shipbuilding and repair industry is engaged in building, conversion, alteration, and repair of all types of ships, barges, and lighters. These activities encompass a broad range of functions, such as: erection of structural steel frameworks and fastening steel plates to the framework to form a hull; application of paint systems to hull; installation of a variety of mechanical, electrical, and hydraulic equipment within the structure; repair of damaged vessels; replacement of expended or failed paint systems; and restoration of malfunctioning equipment and systems to operational condition. Typical of the trade skills involved in this industry are: shipfitters; metalsmiths; welders and burners; machinists; electricians and electronic technicians; pipefitters and coppersmiths; carpenters, joiners and patternmakers; painters; riggers and laborers; blacksmiths; boilermakers; and foundrymen. Not all of the listed activities,

functions, or trade skills are utilized at every facility. Some of the functions require placing the ship into drydock, e.g., replacing underwater paint systems. Only those facilities providing drydocking capabilities are covered in this document.

Graving Dock Description

Graving docks are constructed with sides and a bottom and with a gate at the water end. The bottom is located below the adjacent water surface level with sufficient depth to allow floating of a vessel into the dock. Operations consist of positioning keel blocks on the bottom of the dock to match the keel surface of the ship, flooding the dock by opening valves, opening the gates, positioning the vessel over the keel blocks, closing the gates, and pumping the water out of the graving dock. During maintenance operations, the graving dock is kept dry by sump or stripping pumps which remove fluids and water by providing suction through drains located at low points in the dock. After completing operations on the vessel, the dock is flooded, the gates are opened, and the vessel is floated out of the dock. The gates to the graving dock are closed and the water is pumped out to make preparations for receiving another vessel, or, if identical vessels are being maintained, the next vessel is moved into the dock prior to removing the water.

Graving docks are usually constructed of concrete although they may occasionally be of timber or steel sheetpile cell construction. Figure III-1 illustrates typical cross section and plan views of a concrete graving dock and includes the designations of drydock features.

The preferred method of entrance closure is by floating caisson. Other available types of closure are: miter gates, flap gates, set-in-place gates, sliding caissons and rolling caissons. Floating caissons are watertight structures with flooding and dewatering systems for operation. For design of hull, floating stability, and all operational purposes, they are symmetrical both transversely and longitudinally. Miter gates were probably the first satisfactory mechanical gates. Each closure consists of a pair of gate leaves, hinged at the dock walls, swinging horizontally so that when closed, the free ends meet in fitted contact. Gates are moved by means of a hawser to a nearby power capstan. The sides and bottoms of the gates bear against seats in the drydock walls and floor. A flap gate is a rigid, one-piece gate hinged at its bottom, and swinging downward and outward. It is a compartmented structure with means for varying its bouyancy for raising and lowering. Set-in-place gates are in various forms, and may be built in one piece or multiple sections. They are of beam and plate construction, with reactions carried to the walls by girders and to the floor by beams. Sliding caissons and rolling caissons are built-in box shapes, mounted on hardwood sliding surfaces

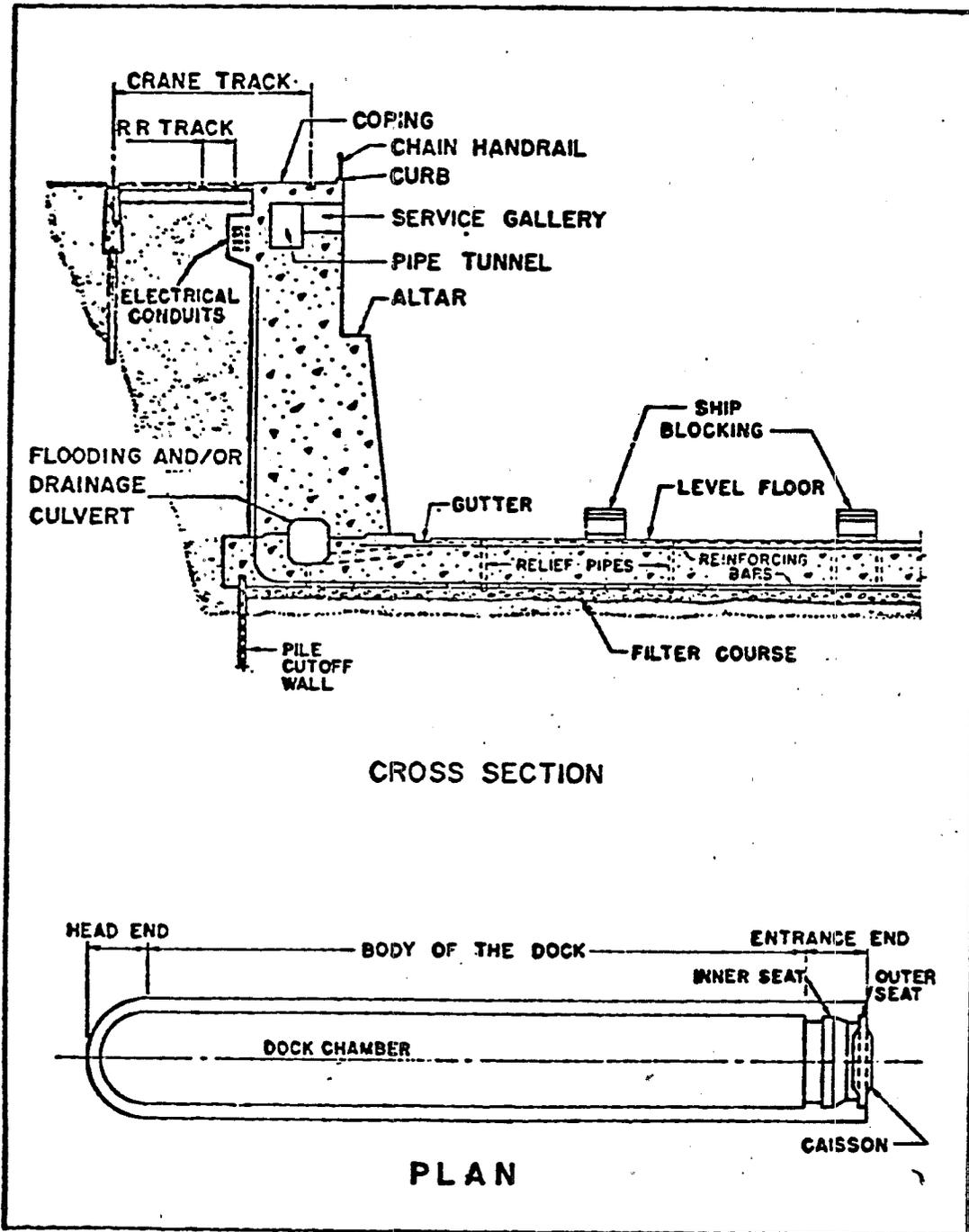


Figure III-1. Typical Graving Dock

or metal rollers which move them into or out of place. They may be equipped with air chambers for bouyancy which reduce the work of moving.

There are three general methods used for admitting water into graving docks. These methods are: (1) through culverts built into the lower parts of sidewalls and connected to floor openings spaced along a dock length, (2) through culverts passing transversely under the floor near the entrance with openings leading upward into the floor, or (3) through ducts in an entrance closure caisson.

Graving docks have two dewatering systems. The collector channel, a wide, deep, grating covered open culvert leading to the pump suction chamber, handles the greater portion of water pumped out of the flooded graving dock. Installation of a settling basin may be justified because abrasive materials harmful to pumps and pump fittings may be washed off a graving dock floor into the pumping system where damage may result.

The main dewatering system of a drydock usually includes: (1) the suction inlet located within the dock chambers; (2) the suction passage and culvert; (3) pump suction chamber; (4) pump suction bells; (5) pumps; (6) discharge, check, and gate valves; (7) discharge culvert including backwash trash rack; and (8) hinged stop gate. Where pumping plants are designed to remove water from more than one dock, additional sluice gates are required to permit independent pumping of the docks. At least two main dewatering pumps are usually required to achieve reasonable dewatering times.

A secondary system collects the last few inches of water blanketing the graving dock floor. This system has sloping longitudinal floor drain culverts near the sidewalls which lead to collector channels at pump wells. The culverts may have rectangular cross-sectional areas of several square feet. They are covered by securely anchored strong gratings. Drainage and sump pumps, of lesser capacity than the main dewatering pumps, are provided to remove seepage, precipitation, caisson and valve leakage, and wash water, and to clear the dewatering pump suction chamber and drainage system.

Ships in graving docks do not ordinarily fill all their own requirements for mechanical services essential for work, habitation, comfort, and protection. Some services, particularly those required for repairs and cleaning associated with the docking operations, must be supplied from dockside facilities. Such services include the delivery of steam, compressed air, water, systems for tank cleaning, and oxygen and acetylene or electricity for welding. Utility services are provided to ships in drydock by lines from service galleries located around the upper perimeter of the dock. The drydock also has a tank cleaning system. Means must be provided to keep a docked

vessel far enough above the floor to permit work on its keel, giving proper allowance for removal or installation of sonar domes, rudders, propellers, and similar parts. Blocking arrangements are laid out in the dock in accordance with the docking plan for each individual vessel. Keel blocks are placed under the longitudinal centerline keel of the vessel. Bilge or side blocks are located according to dimensions indicated in the table of offsets on the vessel's docking plan. In some cases, block slides are built into the dock itself. In addition, such supporting facilities as industrial shops, transportation facilities, weight and materials handling equipment, personnel and storage facilities are normally located in close proximity to drydocks.

Floating Drydock Description

As implied by its name, a floating drydock floats on the water with the bottom of the drydocked vessel above the water surface. The floating drydock is a non-self-propelled mobile structure. The floating drydock consists of a platform and associated ballast tanks used to raise ships above the water level for work which requires exposure of the entire hull. Ballast tanks are flooded and the dock platform is submerged to a predetermined level beneath the water's surface. A ship is then moved over the dock and positioned over preset keel and bilge blocks on the floor of the dock platform. This position is maintained as the ballast tanks are dewatered. Dewatering the ballast tanks lifts the ship and drydock platform floor above the surface of the water (Reference 4).

The following discussion of the sinking and refloating procedures along with a schematic representation of the action is quoted from Appendix A of Reference 4.

"Many different types of floating drydocks have been developed. The specific characteristics of the various types differ considerably as a consequence of the different requirements dictated from considerations of technical, operational, or strategic nature. However, the basic general features and the related terminology are, more or less, the same for all types of docks.

'Figure III-2 illustrates the various parts of a typical floating drydock. The nomenclature used in the figure is standard.

'The lower, horizontal portion of a U-shaped trough which forms the dock structure is called the pontoon. The top of the pontoon, the pontoon deck, forms a platform on which are three or more rows of blocks which support a ship when docked. The pontoon constitutes the main platform for the work to be performed on the docked ship. In order to increase the working

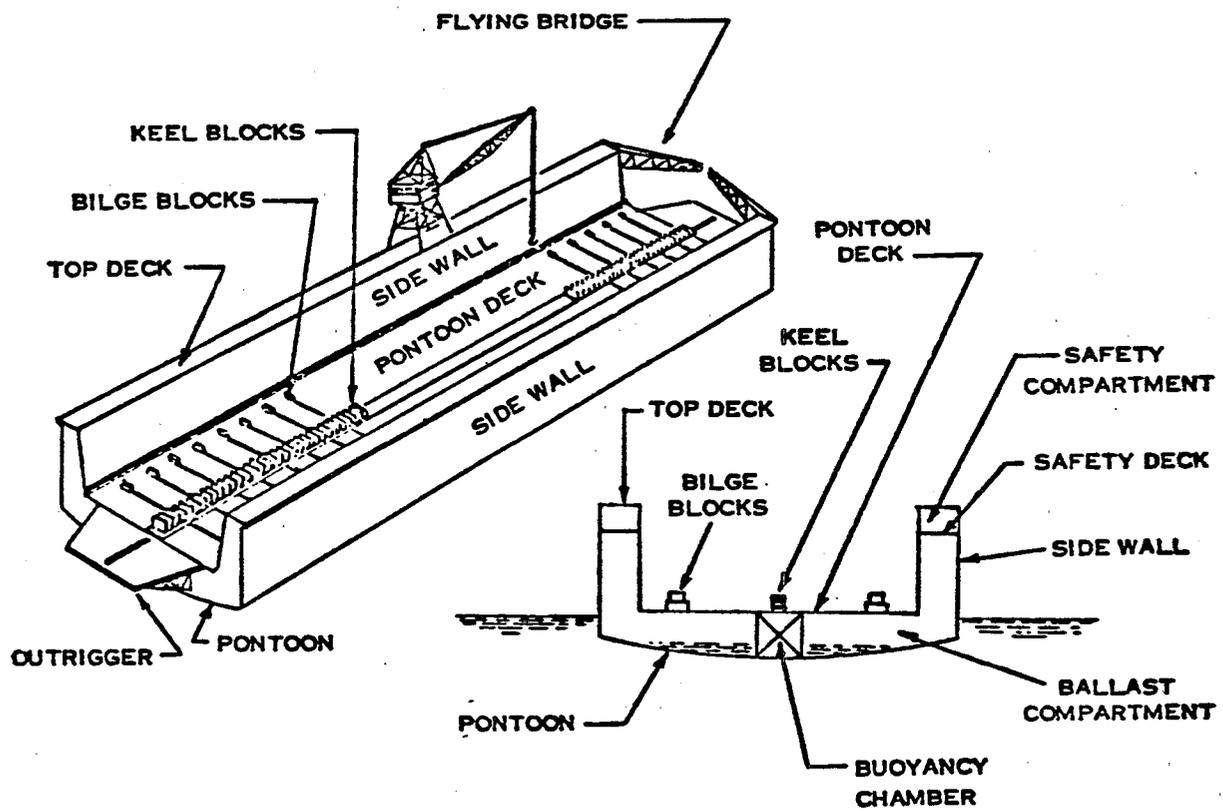


FIGURE III-2. Typical Transverse Section of a Floating Drydock

platform, cantilevered extensions, outriggers, are fitted at the ends of the pontoon deck. The outriggers do not bear any part of the ship's weight, but are particularly convenient for setting up staging around the ends of a long ship.

'Above the two sides of the pontoon stand the side walls. The side walls extend vertically to form, with the pontoon, the U-shape of the dock trough. The top of the side walls is sufficiently high as to be afloat when the dock is submerged to receive the largest ship it is capable of docking. The side walls usually extend to the full length of the dock. The top deck of each side wall provides the necessary equipment and working space for handling the ship's docking lines. Gantry cranes required for handling material travel on tracks along the length of the top decks.

'Flying bridges are often installed at one or both ends of the top decks, to provide personnel passage between the top decks. They consist of hinged cantilever arms, which can be swung open to permit the ship to enter or leave the dock.

'Most of the space contained within the pontoon and side walls is utilized as ballast tanks. The admission of water to or its removal from these spaces creates the forces that cause the dock to submerge or rise. The remaining space consists of chambers which keep the dock afloat and their size determines the limit to which the dock will submerge when all ballast tanks are full. Spaces, termed buoyancy chambers in the pontoon and the safety compartments in the wing walls, serve this purpose. These buoyancy chambers, not being subject to flooding, may also be utilized to accommodate machinery, equipment, personnel quarters, mess rooms, workshops, and stowage spaces.

'The larger floating drydocks are sectionalized to facilitate movement overseas and to render them capable of self-docking. They can transit the Panama Canal.

'One type of floating drydock, the closed basin, ARD type, differs somewhat in design and operation from the other docks. The forward end of the dock is closed by a structure resembling the bow of a ship; the aft end is opened and closed by operation of a stern gate. Lift forces are provided by emptying the ballast tanks and by emptying the dock basin.

'Figure III-3 shows typical inside and outside water levels for a complete docking cycle."

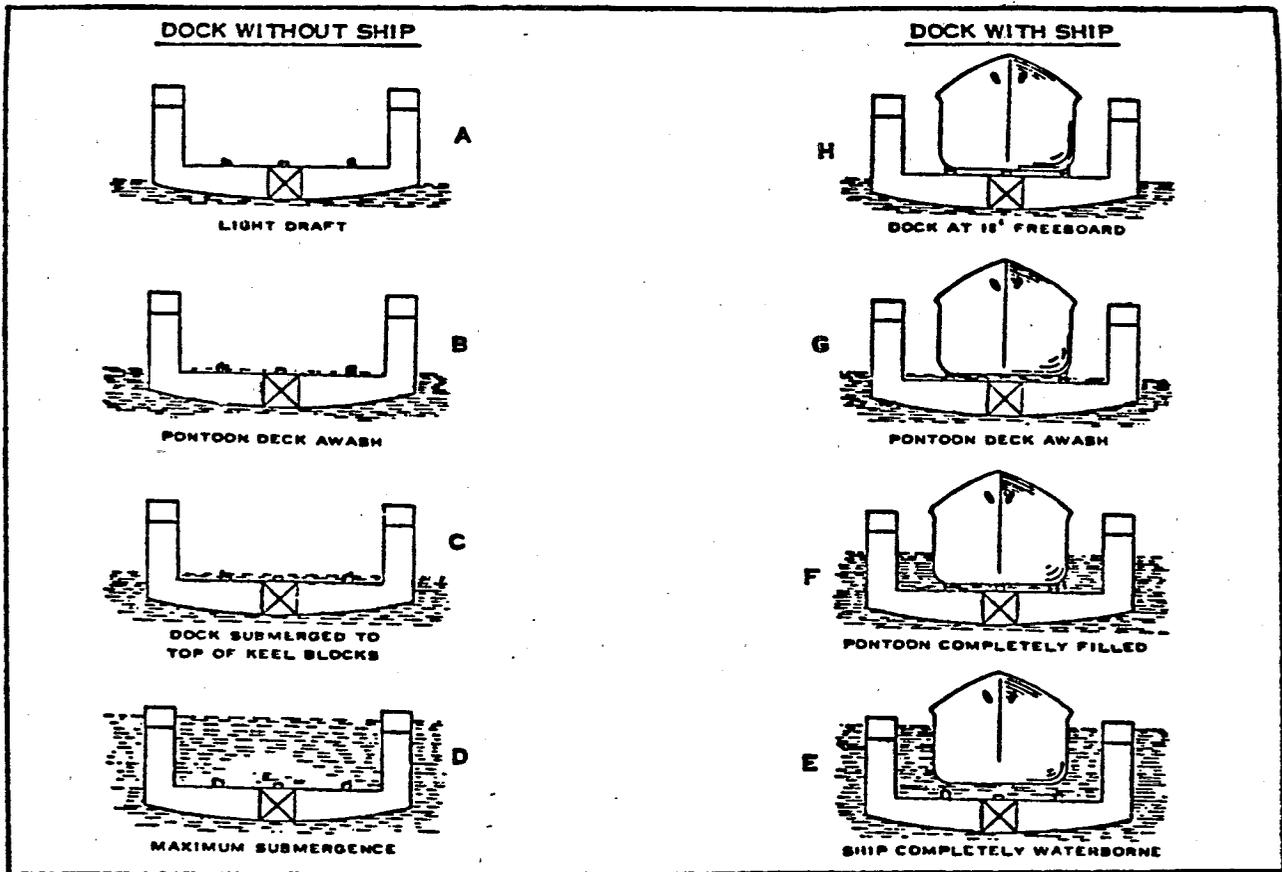


FIGURE III-3. Typical Inside and Outside Water Levels For Complete Docking Cycle of Floating Drydock

Shipyard Practices

This section is limited to discussion of those operations normally or most frequently performed in drydock with full recognition that almost the entire range of activities listed in "Activities Carried Out at Shipyard Facilities" above are available and may on occasion be required. The basic functions of a drydock are the construction and repair of ships and the cleaning, and painting of ships' bottoms, propellers, rudders, and the external parts below the water line.

Drydocks provide access to the ship's bottom and utilities services to shipyard personnel. Drydocks supply gas, electricity, steam, compressed air, fresh water, and salt water to the ship in drydock from lines attached to or embedded in the drydock. Processes involved in drydocking include docking, undocking, tank cleaning, abrasive and chemical paint removal, painting and mechanical repair of various ships' parts. Mechanical repairs of machinery, welding, cutting of plates, and alterations of a ship's structure are other functions performed in drydock (Reference 5).

Tank cleaning operations remove dirt and sludges from fuel tanks and bilges on the ship. Workmen spray detergents, or hot water, into the emptied tanks by injecting cleaners into the steam supply hoses. Spent wash water in the tanks is pumped by Wheeler (TM) machines, which are combination pump and storage tank units, into tank trucks or barges for subsequent disposal (Reference 5).

The almost universally preferred method of preparing steel surfaces for application of a fresh paint system for saltwater immersion is dry abrasive blasting. For solely freshwater immersion, light hydroblasting (a water sweep) may be adequate to remove loose, flaking or non-adhering paint in preparation for refurbishing paint systems.

With the exception of the closed-cycle blast machines being currently being developed and evaluated, all blasting presently carried out within drydocks is done manually. Three manual blasting methods are used within drydocks, and the characteristics of the debris produced by each method are markedly different.

Dry abrasive blasting is a process by which the blasting abrasive is conveyed in a medium of high pressure air, through a nozzle, at velocities approaching 450 feet per second. This type of blasting produces the highest relative amount of dust, and resulting residues are dry. Dry blasting is used for virtually all tank interior work and extensively on exterior hull work (Reference 6).

The two other manual blasting methods are wet abrasive blasting in which water replaces air as the propellant and water cone blasting in

which a spray of water surrounds the air driven abrasive streams (Reference 7).

Organotin antifouling paints may produce toxic dust if subjected to dry blasting. Thus, wet blasting techniques are used when removing these paints (Reference 6). Wet or slurry blasting is also used in cleaning special underwater equipment, such as resin-constructed sonar domes, to protect them from damage (Reference 8). Wet blasting procedures significantly reduce dust occurrence. A rust inhibitor may be added to the water or slurry to prevent rusting of surfaces before painting. Rust inhibitor solutions may vary but usually will be composed of diammonium phosphate and sodium nitrite along with the abrasive grit and water.

An abrasiveless method of blasting using jets of high pressure water, hydroblasting, has been demonstrated for some purposes. Generally, this will only remove surface debris and loose or flaking paint. By going to very high pressures, on the order of 10,000 psi, adhering paint can be removed to bare metal. Hydroblasting is rarely used in shipyard operations.

Blasting practices were found to vary widely between facilities. Many factors influence this, some of which are discussed later in this section. Table III-2 summarizes the blasting practices used in shipyards visited during the conduct of this study. Type of blasting, frequency of occurrence, amount of paint removal, and blasting medium are qualitatively indicated, as are the type and number of docking facilities.

Table III-2

ABRASIVE BLASTING

| Ship- yard | Facilities FD | Type of GD Blasting | Frequency | Usual Amount of Paint Removal | Blasting Medium* |
|---------------|------------------|-----------------------------|-----------|--|---|
| A | 3 | 1 Dry | Usually | Usually to Bare Metal | Camel Black |
| B | 0 | 5 Dry | Usually | Depends on Vessel, Sand Sweep to Bare Metal | Black Beauty |
| C | 0 | 2 Dry | Rarely | None | NA |
| D | 2 | 3 Dry, Also Closed Cycle | Usually | Usually to Bare Metal | Kleen Blast |
| E | 0 | 1 Dry | Usually | Depends on Vessel | Kleen Blast |
| F | 0 | 2 Dry | Rarely | Only for Repair Work | Black Beauty Campbell Black #2 |
| G | 2 | 0 Dry | Usually | Depends on Vessel, Never to Bare Metal | Sand Blast |

*By trade name.

FD = Floating Drydock, GD = Graving Dock, NA = Not Applicable

Of the seven facilities visited, none uses wet blasting routinely and only one indicated its use on rare occasions. Shipyard F uses abrasive blasting only in conjunction with repair work such as welding.

There are two techniques in use for dry abrasive blasting. The first, generally known as "sand sweep," is frequently used on commercial vessels to remove marine growth, fouling and delaminating coatings only in preparation for refurbishment or renewal of paint systems. The second, more frequently used on naval vessels, removes marine growth, fouling, and all paint down to "white metal" and abrades the metal substrate to provide a suitable surface for adherence of a complete fresh coating system.

The following procedure quoted from Reference 9, describes the entire cycle of abrasive blasting. It applies equally well to dry or wet abrasive blasting except for addition of water at the appropriate point in the cycle. It should be noted that the full cycle is not carried out at all shipyards - e.g., some facilities have the grit delivered to their site in the hoppers from which it flows into the pressure pot.

"Procedure

- o Abrasive is delivered in large quantities as a free flowing material by covered railway hopper car or dump truck.
- o Abrasive is transferred from shipping unit to storage areas by allowing abrasive to flow from shipping unit onto conveyer belts that dump it into forklift hoppers or directly into storage bins. Usually, abrasive storage will be covered by a permanent structure or temporary covers (canvas or plastic tarpaulin).
- o When abrasive is required, large hoppers, in excess of 6-ton capacity, are loaded by scoop tractor or vacuum loaders. When full, these hoppers are transferred to the job site by forklift truck.
- o Abrasive from these hoppers is transferred into the pressure pots, usually by gravity feed.
- o Finally, the abrasive is propelled from the sandblast nozzle by compressed air to forcibly impinge on the surface being cleaned.
- o Spent abrasive, paint particles, fouling organisms, and other debris fall to the drydock floor.

- o The debris from the sandblast operations is picked up by scoop tractors, hand shovels, and/or other method for transfer to hoppers or skip boxes.
- o In some shipyards, spent metallic abrasive is reclaimed and reused, but abrasive contaminated with antifouling paint is discarded in designated landfill areas."

The abrasive may be either metallic or nonmetallic. Practically all blasting is done with certain by-product mineral abrasives which are low in free silica content. The specification (Reference 10) used by naval shipyards purchasing grit allows a maximum of 5 percent free silica content. The constituents of abrasive blast materials currently in use by U.S. Naval Shipyards are shown in Table III-3. Rationales of naval shipyards for purchasing particular abrasives include: low free silica content; less dusting; performance; availability; and price (Reference 8). Commercial facilities use the same or similar materials for like reasons.

Ships in drydock may be painted internally, on the hull and on the superstructure. Because the painting of the superstructure does not require a dry hull and because drydock availability is limited and expensive, superstructures are frequently painted while the ship is at berth or at sea. The bulk of painting activity in a drydock is on a ship's hull and internal fuel and water tanks. Anchor chains, anchors and portable ships' machinery are frequently placed on wooden pallets in the drydock for painting. Paints applied to protect metal from corrosion or fouling are sprayed onto most surfaces although painting of irregularly shaped objects such as chains is sometimes performed with brushes. Occasionally paints are applied to flat or gently curving surfaces by roller.

There are two kinds of paint spraying equipment in use. One uses a stream of compressed air to convey the paint from container to surface being painted. A newer method rapidly increasing in use employs hydrostatic pressure to convey the paint. It is claimed that airless paint spraying is more efficient because of very low paint loss due to drift or overspray. Almost all of the paint is applied to the intended surface. Estimates of losses due to drips, spills, and overspray range from 1 to 2% for airless paint spraying. Observations during shipyard visits of spills while mixing, noticeable overspray from airguns, and concentrations of droplets on the surface of water running through drainage gutters generates more confidence in the higher than in the lower figure. Occasionally, flowing water is purposefully used to carry spilled paint into drainage gutters.

Anticorrosive and antifouling paints are typically used on ships in drydocks. To these paints may be added differing pigment materials such as lampblack, red iron oxide, or titanium dioxide to achieve a

Table III-3. CONSTITUENTS OF ABRASIVE BLAST MATERIAL
AT NAVAL SHIPYARDS

CONSTITUENTS % BY WEIGHT (SEE NOTE)

| FACILITY ABRASIVES | IRON OXIDE | CALCIUM OXIDE | POTASSIUM OXIDE | ALUMINUM OXIDE | MAGNESIUM OXIDE | SODIUM OXIDE | COMBINED SILICON DIOXIDE | COPPER | CHROMIC OXIDE | TITANIUM | MANGANESE | ZINC OXIDE | FREE SILICA | SULFUR | OTHER |
|-----------------------|------------|---------------|-----------------|----------------|-----------------|--------------|-----------------------------|--------|---------------|----------|-----------|------------|-------------|--------|-------|
| PORTSMOUTH | | | | | | | | | | | | | | | |
| BLACK DIAMOND | 28 | 6.14 | | 21 | 1.1 | | 43 | | | .95 | .04 | | | .15 | .17 |
| PHILADELPHIA | | | | | | | | | | | | | | | |
| POLYGRIT | 42 | 12 | .03 | 11 | 2 | 1 | 17 | .7 | 1 | | | 13 | | | |
| NORFOLK | | | | | | | | | | | | | | | |
| BLACK BEAUTY | 35 | 4 | 2 | 23 | 1 | 1 | 34 | | | | | | | | |
| CHARLESTON | | | | | | | | | | | | | | | |
| SAF-T-BLAST | 28 | | | 21 | | | 50 | | | 1 | | | | | |
| LONG BEACH | | | | | | | | | | | | | | | |
| KLEEN BLAST | 19 | 19 | | 9 | 2.9 | | 48 | .1 | | | .22 | | | | |
| MARE ISLAND | | | | | | | | | | | | | | | |
| GREEN DIAMOND | 23 | .6 | | 1 | 23 | .05 | 52 | | .04 | | | | .3 | .01 | |
| PUGET SOUND | | | | | | | | | | | | | | | |
| BLACK DIAMOND | 17 | 22 | .7 | 9 | 3 | .2 | 36 | .6 | .5 | | | 12 | | | |
| ROCK-WOOL SLAG | 16 | 26 | 2 | 9 | 3 | 1 | 39 | .2 | .5 | | | 4 | | | |
| PEARL HARBOR | | | | | | | | | | | | | | | |
| BLACK DIAMOND | 19 | 19 | | 9 | 3 | | 48 | .1 | | | .22 | | | | |
| HAM | | | | | | | | | | | | | | | |
| GREEN DIAMOND | 23 | .6 | | 1 | 23 | .05 | 52 | | .04 | | | | .3 | .01 | |

NOTE: Totals may not equal 100 due to rounding off. Since percentages vary between lots, these values are approximations of the average.

Table III-4. COMPOSITIONS OF FORMULA PAINTS

| Formula No. | Mil. Spec. No. | Composition | lb/100 gal | gal/100 gal | |
|-----------------------|----------------|--|------------|-------------|--|
| 117 Anti-corrosion | Mil.P-15328 | Polyvinyl-butyril resin | 56 | 6.10 | |
| | | Zinc chromate | 54 | 1.59 | |
| | | Magnesium silicate | 8 | 0.35 | |
| | | Lampblack | 0.6 | 0.04 | |
| | | Butyl alcohol | 125 | 18.40 | |
| | | Ethyl alcohol | 482 | 70.70 | |
| | | Phosphoric acid | 28 | 2.0 | |
| | | Water | 25 | 3.0 | |
| 119 Anti-corrosion | Mil.P-15929 | Rod Lead | 220 | 2.9 | |
| | | Vinyl resin | 145 | 12.8 | |
| | | vinyl chloride | | | |
| | | vinyl alcohol | | | |
| | | vinyl acetate | | | |
| | | Tricresyl Phosphate | 15 | 1.5 | |
| | | Methyl Isobutyl Ketone | 295 | 43.8 | |
| | | Toluene | 295 | 40.0 | |
| 121 Anti-fouling | Mil.P-15931 | Cuprous oxide | 1440 | 27.40 | |
| | | Rosin | 215 | 23.07 | |
| | | Vinyl resin | 55 | 4.69 | |
| | | Tricresyl phosphate | 50 | 4.92 | |
| | | Methyl Isobutyl Ketone | 165 | 23.88 | |
| | | Xylene | 115 | 15.42 | |
| | | Anti-settling agent | 5 to 9 | 0.62 | |
| | | | | | |
| 129 Anti-fouling | Mil.P-16189 | Cuprous oxide | 1120 | 21.62 | |
| | | Lampblack | 70 | 4.50 | |
| | | Rosin | 185 | 19.83 | |
| | | Vinyl resin | 45 | 3.84 | |
| | | Tricresyl phosphate | 40 | 3.93 | |
| | | Methyl Isobutyl Ketone | 200 | 28.92 | |
| | | Xylene | 130 | 17.42 | |
| | | Antisetting agency | 5 to 9 | 0.64 | |
| | | | | | |
| | | | | | |
| 1B30 | Mil.P-24441 | Thixatropo | 10 to 20 | | |
| 1B29 | | Polyanide | 20 | | |
| 1B27 | | Polyamide adduct | 280 to 320 | | |
| 150 | | Magnesium silicate | 250 to 600 | | |
| 151 | | Titanium dioxide | 5 to 600 | | |
| 152 | | Butyl alcohol | 253 to 304 | | |
| 153 | | Copper phthalocyanine blue | 0 to 1 | | |
| 154 | | Yellow iron oxide | 0 to 500 | | |
| 155 | | Red iron oxide | 0 to 300 | | |
| | | Epoxy resin | 500 to 586 | | |
| | Naptha | 215 to 258 | | | |
| Anti-corrosive | | Diatomaceous silica | 0 to 150 | | |
| | | Lampblack | 0 to 18 | | |
| | | | lb | | |
| 1020A Anti-fouling | | Vinyl resin | 161 | 16.1 | |
| | | -bis (Tributyltin) oxide | 38.3 | 4.0 | |
| | | Tributyltin fluoride | 167 | 16.1 | |
| | | Carbon black | 19.4 | 1.3 | |
| | | Titanium dioxide | 7.2 | 0.2 | |
| | | Ethylene glycol mono- ethyl ether acetate | 28 | 3.4 | |
| | | Normal prepanol | 102 | 15.1 | |
| | | Normal butyl acetate | 400 | 54.8 | |
| | | | | | |

particular decorative or camouflage effect. Table III-4 presents the chemical composition of the most commonly used external hull paints on navy ships.

The anticorrosive paints are either vinyl or vinyl and lead based, or are of the newer epoxy type which is slowly supplanting the vinyl and vinyl-lead paints. Substantial quantities of both types of paints are being used in shipyards, with some epoxy paints of unknown exact compositions being supplied by manufacturers but having characteristics essentially similar to the Navy standard formula. Both types of paints will be removed by abrasive cleaning methods.

Antifouling paints are designed to prevent growth and attachment of marine organisms on hulls of ships by releasing minute quantities of toxic substances in the immediate vicinity of the hull surface. Copper-based paints using cuprous oxide have been the standard for many years (Reference 5). The use of organotin paints is very recent, but growing. Tributyl tin fluoride (TBTF) and tributyl tin oxide (TBTO) are the principal toxicants. Table III-5 identifies some organotin antifouling paints commercially available.

Table III-5

COMPOSITIONS OF
ORGANOTIN ANTIFOULING PAINTS

| <u>Identification</u> | <u>Contents</u> |
|---|--|
| M.I. Formula 1020A | Vinyl/TBTO/TBTF |
| Devran MD-3198 | Vinyl/TBTF |
| Amercoat 1795 | Vinyl/TBTO |
| Tarset 305 | Coal tar epoxy/TBTA |
| Andrew Brown Colortox (Brolite Z-Spar) | Vinyl/TBTF |
| M.I. Formula 1010 | Vinyl/TBTO/10,10 ¹ -oxybis- phenoxarsine |
| M.I. Formula 1028 | Vinyl/rosin/TBTF/Cu ₂ O |
| Biomet | Vinyl/TBTF |
| M.I. Formula 1011 | Vinyl/TBT neodecanate/TBTF |
| Devoe XM-075 | Epoxy/Cu ₂ O/TBTO |
| Rustban VY-5529 | Vinyl/TBTF |
| Glidden No-Cop AF | Vinyl/TBTO |
| International Tri-lux 40 (wide spectrum AF, Mark I) | Vinyl/TBTF |
| International Tri-lux 68 (wide spectrum AF, Mark II) | Vinyl/TBTF |

Note: TBTO = Tributyl Tin Oxide
TBTF = Tributyl Tin Fluoride

Reference 11

The industrial operations carried out in drydocks result in considerable amounts of debris collecting on the dock floor. This debris consists of:

- o Marine organisms removed from the hull by washing or blasting
- o Spent grit from abrasive blasting (whether wet or dry)
- o Old paint particles, flakes, and chips abraded from the hull
- o Rust particles and flakes abraded from the hull
- o Fresh paint dripped, spilled, or oversprayed onto the other debris during application to the hull, machinery, or equipment.

These materials have constituents that are potential pollutants to adjacent navigable waters. In addition to the pollution potential, the debris is a hindrance to further industrial operations in the drydock, a wear hazard to dewatering and drainage pumps, a weight addition to floating drydocks, and an inconvenience to people who must work in the dock. All shipyards clean up and remove the debris but there is wide variation in the frequency, technique, and thoroughness.

In addition to ship repair and maintenance practices, other factors can affect the kind and amount of wastes generated in drydock. During the conduct of this study it was established that wide differences exist between practices at shipyards and between conditions existing at each yard. These differences also influence the waste load generated. Among the factors noted as having impacts upon waste generation are:

- o Location - fresh vs. saltwater
- o Type of ships serviced
- o Extent of utilization and time of stay in dock
- o Type of facility, configuration, and age
- o Clean-up practices

Table III-6 summarizes, for facilities visited, factors relevant to the drydock location which bear upon the quantity and type of waste.

Table III-6

LOCATION FACTORS

| <u>Ship- yard</u> | <u>Location</u> | <u>Type of Water at Facility</u> | <u>Climate</u> | <u>Predominant Vessel Service</u> | <u>Predominant Type of Vessel</u> |
|-----------------------|-----------------|--|----------------|---|---|
| A | East Coast | Brackish | Moderate | Ocean | Commercial |
| B | East Coast | Salt | Moderate | Ocean | Commercial & Naval |
| C | West Coast | Salt | Moderate | Ocean | Commercial |
| D | West Coast | Salt | Very Dry | Ocean | Naval |
| E | West Coast | Salt | Very Dry | Ocean | Naval & Commercial |
| F | Great Lakes | Fresh | Moderate | Inland | Commercial |
| G | Gulf Coast | Fresh | Wet | Inland & Ocean | Commercial |

The facilities located in the Great Lakes and Gulf Coast areas were both on river sites. The Great Lakes yard, however, services only inland waterways vessels while the Gulf Coast yard services both ocean and inland vessels. All other yards which were visited service predominantly oceangoing vessels. Also shown in Table III-6 are the ownership, commercial, or naval, of the ships predominantly serviced. The two factors, ocean vs. inland, and naval vs. commercial, have a major influence on the operations in the dock and the wastes produced. Oceangoing vessels generally require antifouling paints while freshwater vessels as a rule do not. Thus, antifouling paints are removed from oceangoing vessels when repainting is needed. This does not occur in strictly freshwater operations.

The seven facilities visited included two on the West Coast, three on the East Coast, one on the Gulf, and one on the Great Lakes. Of these seven, two facilities had freshwater locations, four had ocean locations, and one was located on an internal body of water. Two facilities were naval and the balance were commercial. Finally, the age and condition ranged from over fifty years and poor to one year and excellent.

Naval vessels enter drydock for extensive maintenance. During the course of this maintenance, the antifouling and anticorrosive paints are removed to bare metal. Extensive paint removal is not usually practiced on commercial vessels. In general, freshwater commercial ships may receive no blasting prior to repainting, while naval vessels are completely refurbished from bare metal. Thus, larger quantities of spent paint and abrasive usually result from work on naval vessels than from commercial ships.

A number of other factors act to create differences in drydocking and service practices between naval and commercial vessels. Commercial vessels customarily are drydocked annually or biennially for inspection. During these drydockings, hull repainting may be undertaken; however, due to the short period between drydockings, paint deterioration may not be severe and fouling may be minimal or moderate. In addition, commercial vessels are usually on the move and this reduces the amount of fouling which can occur. Naval vessels are drydocked on a routine basis at intervals of up to five years or more. Hull preparation and painting must be designed to provide protection for that period, thus cleaning to bare metal and the use of higher levels of toxicants in antifouling paints than for commercial vessels is customary. Since naval vessels spend much time in port or at anchor, the potential for fouling is more severe than if they were underway.

Utilization of the drydocking facilities is another factor which influences the total waste generated. Yards contacted indicated utilizations ranging from 30 percent to 100 percent. A drydock which

is used infrequently or intermittently has less total discharge than one operating on short turnaround service at a high rate of utilization. Facilities used for new construction usually are occupied by the activity for periods in excess of a year. In this case, not only is the nature of the operation less productive of waste (no spent paint to blast off the hull) but flooding occurs only at launch, once per ship. Table III-7 summarizes drydock utilization for yards contacted and visited.

Table III-7

UTILIZATION OF DRYDOCKING FACILITIES

| | Percent Utilization ¹ | | | | |
|------------------------------|----------------------------------|--------------|--------------|--------------|---------------|
| | <u>0-30</u> | <u>31-50</u> | <u>51-70</u> | <u>71-90</u> | <u>>90</u> |
| <u>Facilities Visited</u> | | | | | |
| Graving Docks | 2 | 0 | 2 | 2 | 2 |
| Floating Drydocks | 0 | 0 | 3 | 5 | 2 |
| <u>Facilities Contacted</u> | | | | | |
| Graving Docks | 2 | 7 | 2 | 5 | 4 |
| Floating Drydocks | 6 | 13 | 6 | 20 | 1 |
| Building Basins ² | | | | | 2 |
| <u>Totals</u> | | | | | |
| Graving Docks | 4 | 7 | 4 | 7 | 6 |
| Floating Drydocks | <u>6</u> | <u>13</u> | <u>9</u> | <u>25</u> | <u>3</u> |
| TOTAL | 10 | 20 | 13 | 32 | 9 |

¹Information not available: Graving Docks, 8;
Floating Drydocks, 20.

²Not included in totals.

Geographic factors can have a major influence on wastewater from drydocking facilities, especially from graving docks. Facilities located in regions of low rainfall do not have the problem of rainwater wetting the dock floor. This is true for both floating and graving docks. Thus, in those regions spent paint and abrasive can usually be removed dry. Graving docks are frequently subject to groundwater flows into the dock basin. This problem can be critical in some docks, while for others, it does not exist. Unless provisions are made to confine and remove rainfall and groundwater (hydrostatic relief water), waste may be carried from the dock with the dewatering flows.

The age and type of construction of the drydock can have an effect on the control of waste. Older docks, both floating and graving, tend to be constructed with raised slides for bilge blocks. These produce a series of wide channels, usually six to ten feet wide, extending from the dock center line to the side. Debris from work in the dock collects in these channels and cannot easily be removed. Newer construction has favored flat dock surfaces, with keel and bilge blocks being moved by cranes. Debris can be more easily removed from docks of this construction. Facility size varies considerably. For graving docks this influences the volume of harbor water introduced during flooding and subsequently removed during dewatering. Floating drydocks, during sinking and refloating, are exposed to the normal flow of the body of water in which they are located, and actual contact of water with the floating dock may be many times the volume of water needed to flood a similarly sized graving dock. Table III-8 lists dock sizes and approximate volume (without vessel occupancy) for graving facilities contacted during this study.

Table III-8

GRAVING DOCK LENGTHS AND WATER VOLUMES

| Length of Dock, Meters, (Feet) | | | | | Approximate Dock Volume, No Vessel, Million Cubic Liters, (Million Gallons) | |
|--------------------------------|----------------------|----------------------|-----------------------|-----------------|---|--------|
| <122 (<400) | 122-183 (400-600) | 183-244 (600-800) | 244-305 (800-1000) | >305 (>1000) | | |
| X | | | | | 3.8 | (1.0) |
| | X | | | | 13.2 | (3.5) |
| | X | | | | 13.2 | (3.5) |
| | | X | | | 20.4 | (5.4) |
| | | X | | | 21.2 | (5.6) |
| | | X | | | 21.6 | (5.7) |
| | X | | | | 23.8 | (6.3) |
| | X | | | | 26.9 | (7.1) |
| | X | | | | 27.3 | (7.2) |
| | X | | | | 28.0 | (7.4) |
| | X | | | | 28.4 | (7.5) |
| | X | | | | 32.9 | (8.7) |
| | | X | | | 34.1 | (9.0) |
| | X | | | | 39.0 | (10.3) |
| | | | X | | 42.2 | (11.2) |
| | | X | | | 57.2 | (15.1) |
| | | X | | | 57.2 | (15.1) |
| | | X | | | 58.3 | (15.4) |
| | | X | | | 59.8 | (15.8) |
| | | | X | | 70.8 | (18.7) |
| | | X | | | 73.4 | (19.4) |
| | | X | | | 73.8 | (19.5) |
| | | X | | | 79.9 | (21.1) |
| | | | | X | 92.2 | (24.1) |
| | | | | X | 111.3 | (29.4) |
| | | | | X | 143.8 | (38.0) |
| | | | X | | 173.4 | (45.8) |
| | | | | X | 177.1 | (46.8) |
| | | | | X | 190.4 | (50.3) |
| | | | | X | 213.1 | (56.3) |
| | | | | X | 244.1 | (64.5) |
| | | | | X | 244.9 | (64.7) |
| Totals: | | | | | | |
| 1 | 9 | 11 | 3 | 8 | | |

SECTION IV

INDUSTRY CATEGORIZATION

INTRODUCTION

In the development of effluent limitations guidelines and recommended standards of performance for new sources in shipbuilding and repair drydocking operations, consideration should be given to whether the industry can be treated as a whole in the establishment of uniform and equitable guidelines or whether there are sufficient differences within the industry to justify its division into subcategories. For the shipbuilding and repair industry, the following factors were considered as possible justification for industry subcategorization: dockside and shipboard activities, facility age, salt vs. freshwater facilities, climate, and types of dock. After review, only salt vs. freshwater, and type of dock (graving docks and floating drydock) were found to have distinguishable characteristics.

INDUSTRY SUBCATEGORIZATION

Although there exist distinguishing characteristics, this document will apply to all types of docks with consideration given to site specific differences. Quantitative effluent guidelines, however, cannot be established at this time for drydocks because the nature of the discharge is not conducive to numerical monitoring.

There are such a wide range of dockside activities, nearly all of which are carried on to some degree in all shipyards, that dockside activities are not an acceptable criterion for subcategorization.

FACTORS CONSIDERED

Salt vs. Freshwater

Freshwater yards perform very little abrasive blasting compared with shipyards servicing saltwater vessels. Also, antifouling paints are not applied to freshwater ships. Since blasting is less common and usually on a much smaller scale, and the spent paint composition is different, shipyards servicing only freshwater vessels and those performing neither wet blasting to remove paint nor dry abrasive blasting should receive consideration with respect to their difference. Best Management Practices (See Section II) numbered 2, 5, 7 and 10 do not apply for facilities where wet blasting to remove paint or abrasive blasting does not occur.

Others

All other factors were rejected as bases for subcategorization. Since the major source of potential water pollution appears to result from blasting, the type of shipyard activities also was eliminated as a possible subcategory. Age of the facility does not directly affect the degree or composition of discharge. Because rainfall is unpredictable and occurs to some extent at all yards, climate also was rejected as a basis for subcategorization.

The type of dock, graving dock or floating drydock, also was considered and rejected as a subcategory. The same kinds of activities are undertaken in both types of docks and thus the same kinds of debris and discharges are produced. The only difference is that during flooding and deflooding, the water passes over the ends of and through scuppers along the sides of floating drydocks while it flows through one (or more) collector channels in graving docks and is discharged using pumps.

SECTION V

WATER USE AND WASTE CHARACTERIZATION

INTRODUCTION

This section describes the sources and uses of water by ships and industrial operations in drydocks. Potable water for use within drydocks is drawn from the same source that supports the rest of the shipyard, almost invariably the contiguous municipal system. Non-potable water is most frequently drawn directly from the adjacent navigable waterway.

Water requirements in a drydocking facility can be broadly classified as those necessary for the ship and those associated with the drydock. The former include potable water, cooling water, water for fire control, and other shipboard uses of water. All but potable water are usually supplied from harbor water. Drydock water uses are harbor water for flooding, hosedown of ship and dock surfaces, occasional wet blasting water, and dust scrubber water. Potable water is used in drydocks for tank cleaning operations.

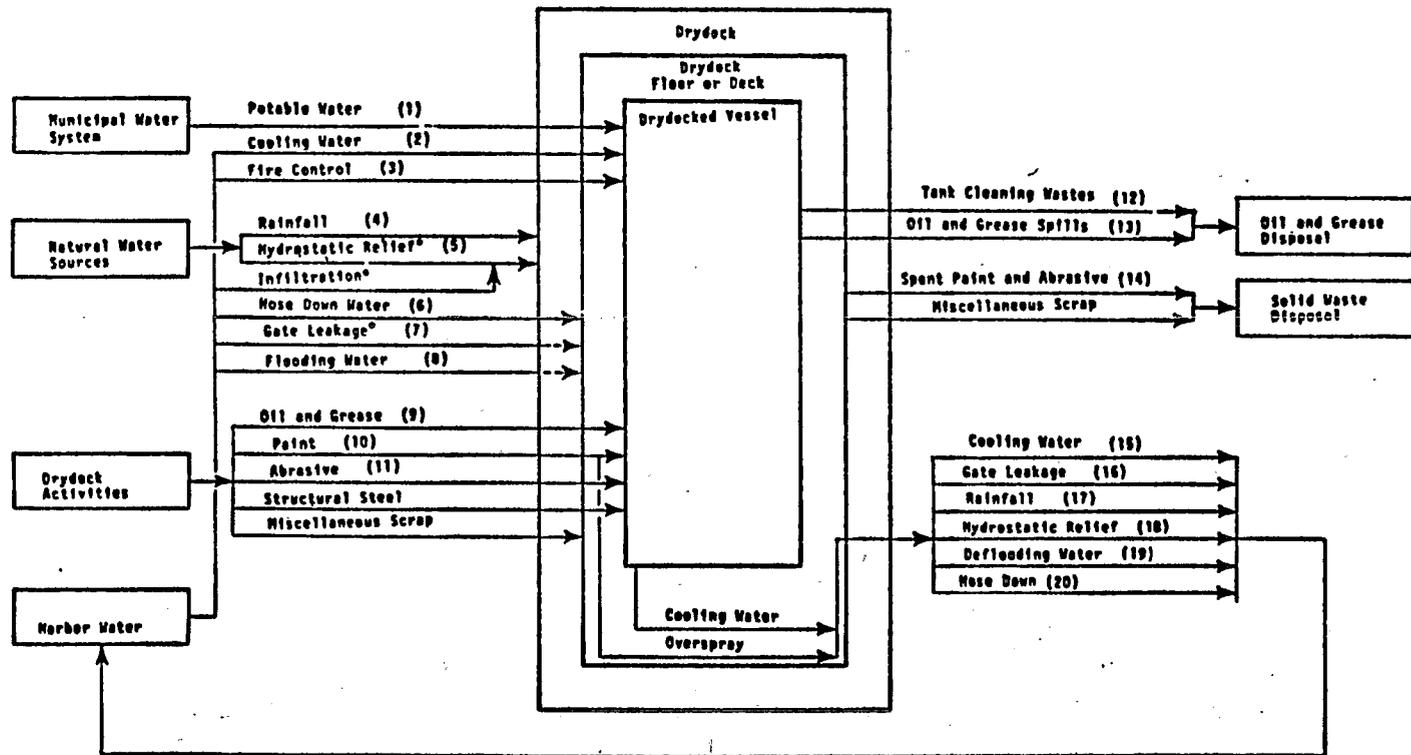
Wastewaters similarly originate from both ship and drydock sources. Ship wastewater includes cooling water discharge, tank cleaning wastes, and occasionally boiler water discards. Drydock wastewater includes deflooding water, hydrostatic pressure relief water and gate leakage, rainwater, water used in hosedown, tank cleaning water, water from wet blasting if practiced, and any water entering the drydock from the ship or other sources.

Figure V-1 is a schematic of water and wastewater flows between a drydock, the drydocked ship, the drydock floor or deck, and the harbor. The figure represents a graving dock; however, if the flows indicated by asterisks are deleted, it also represents a floating drydock.

Not all flows are present in all drydocks. For example, potable water is supplied to vessels only if crews are on board. Hydrostatic pressure relief water is encountered in vast quantities in some graving docks, others are completely free of this stream.

In addition to water and wastewater flows, Figure V-1 shows materials entering the drydock as a result of the repair activities and the disposition of waste materials resulting from repair activities.

Table V-1 summarizes the observations made during the shipyard visits. The numbered streams in Figure V-1 are identified as to their presence or absence at each of yards A through F in Table V-1.



*Denotes flows not applicable to floating drydocks.

FIGURE V-1. Major Flows Associated With Drydocked Vessel

Table V-1. WATER AND WASTEWATER PRACTICES, SHIPYARDS
A THROUGH G

Water and Wastewater Flow Streams⁽¹⁾
In Shipyard Visited

| Stream Number | SHIPYARD | | | | | | |
|------------------------------------|----------|---|----|---|---|---|----|
| | A | B | C | D | E | F | G |
| <u>Water Into Dock</u> | | | | | | | |
| 1 | P | P | P | P | P | A | A |
| 2 | P | P | P | P | P | A | A |
| 3 | P | P | P | P | P | P | P |
| 4 | P | P | I | I | I | P | P |
| 5 | P | P | NA | P | P | A | NA |
| 6 | A | I | A | I | I | I | A |
| 7 | P | P | NA | P | A | I | NA |
| 8 | P | P | P | P | P | P | P |
| <u>Materials Into Dock</u> | | | | | | | |
| 9 | I | I | I | I | I | I | I |
| 10 | P | P | P | P | P | P | P |
| 11 | P | P | P | P | P | I | P |
| <u>Waste Materials to Disposal</u> | | | | | | | |
| 12 | I | I | P | P | I | I | I |
| 13 | I | I | I | I | I | I | I |
| 14 | P | P | P | P | P | I | P |
| <u>Wastewater to Harbor</u> | | | | | | | |
| 15 | P | P | P | P | P | A | A |
| 16 | P | P | NA | P | I | I | NA |
| 17 | P | P | I | I | I | I | P |
| 18 | P | P | NA | P | P | A | NA |
| 19 | P | P | P | P | P | P | P |
| 20 | A | I | A | I | I | I | A |

P - Present, A-Absent, I-Intermittent, NA-Not Applicable to
Floating Drydock

(1) Refer to Figure V-1 for Stream Designation

SPECIFIC WATER USES

Water For On Board Ship Use

Once they have been placed in service, ships are equivalent to small towns with respect to their demand for water and the generation of wastewater discharges. The following subsections describe the source, use, and discharge of water for each of the several systems aboard ship.

Potable Water. Potable water is drawn from supporting facilities when in drydock. In addition to direct consumption by the resident population, it is used for food preparation and personal hygiene. The wastes from these uses become sanitary discharges which are covered by other regulations and will not be further considered in this document, except that they should be segregated from process wastewaters.

Fire Protection Water. While underway, fire protection water is drawn into the vessel from water being sailed upon. It is pressurized for use in the fire protection system. When in drydock, the supporting facility provides non-potable pressurized water for this purpose. These facilities are sometimes used to hose down the dock after dewatering or to help accumulate residual spent abrasive into piles.

Boiler Feed Water. Boiler feed water is either distilled from seawater or drawn from supporting facilities such as drydocks. This type of water is often required to be purer than potable water. In use, it is converted to steam in the boiler. The steam is then used to drive propulsion, electric generation, and other machinery as well as for heating purposes. Finally, the spent steam is condensed into water and fed back into the boiler to begin the cycle again. Since this is a closed cycle system there are not normally any discharges other than unintended leaks. A ship entering a drydock for maintenance and repair may occasionally have work done on the boiler while in drydock, and it may be necessary to drain the water from the boiler.

Cooling Water. Most of the water supplied to a ship in drydock for cooling is non-potable water. Freshwater cooled equipment normally uses a recirculating chilled water system in which little water is wasted. Cooling water is used as a flow through heat sink for air conditioners and various pieces of machinery and electronic equipment. Waste cooling water is discharged from the ship into the drydock in essentially the same condition as supplied except for temperature elevation (References 5 & 11).

Water For Industrial Use

Very little industrial wastewater is generated by the processes carried out in drydocks. However, large amounts of water may pass through the dock basin. Almost none of the drydocks in current use have design provisions for the segregation of contaminated and non-contaminated flows nor do they ensure isolation of non-contaminated flows with regard to possible contamination from contact with industrial process debris. This section will list and describe the source of all waters, except shipboard wastes, which can be potentially contaminated by flow through the drydock basin.

Launch Water, Graving Docks. As described earlier a graving dock basin is ordinarily flooded and dewatered twice for each ship docked. Water is admitted from the adjacent navigable waterway through the flooding culverts or through the caisson gate. The gate is removed, the ship is brought into or removed from the dock, the gate is replaced, and the water is returned to its source by pumping. The quality of the water on return, relative to the source, is dependent upon the condition of the admitted water and upon any material which may be added to or removed from it while in the drydock.

Launch Water, Floating Drydocks. There are two water flows involved in the sinking and raising of a floating drydock. Sinking and raising ordinarily happens twice for each ship docked.

The first water flow is that water admitted to the ballast compartments from the adjacent navigable water body to sink the dock. After the ship is brought into or removed from the dock, water is pumped from the ballast compartments back to the source body, without further contamination, to raise the dock. The return flow may be of better quality than the source since the ballast compartment may serve as a settling tank.

The second water flow is source body water flowing through the open ends of the U-shaped trough of the dock and over the pontoon deck as the dock is sunk. As the dock is raised, water flows out through the ends and other openings of the drydock and returns to the source body. The quality of the return flow, relative to the source, is dependent upon the amount and type of debris that is present on the side wall and pontoon deck surfaces prior to sinking as well as upon the time of exposure and rate of runoff during dewatering.

Wash Down. When a graving dock is flooded, it simulates a large settling tank. Silt and mud which enter the dock with the flooding water deposit on the floor following dewatering. Marine organisms may be trapped inside the dock basin when the caisson is replaced for dewatering. If the dock is not cleaned after dewatering, the dead marine organisms begin to decay and the silt and mud becomes very

difficult to remove (Reference 11). In those facilities where these problems occur, the drydock floor and other surfaces are hosed with water from the pressurized non-potable system. Existing practices generally may include hosing (1) after initial dewatering and (2) prior to final flooding. These practices were observed in two of the seven shipyards visited. There are other times of intermittent hosing. For instance, water from drydock and ship hosing generates liquid industrial waste and, in addition, may convey solid wastes to the drainage tunnel for direct discharge to the receiving waterbody.

Washdown also occurs occasionally after clean up. Solid wastes remaining after mechanical and manual clean up efforts may be flushed by hosing into the drainage tunnel or mixed with flooding waters on the dock floor during the undocking cycle (Reference 6).

Washdown in a floating drydock is identical to that in a graving dock except that the wastes are discharged over the side of the dock instead of into the drainage tunnels.

Integrity Testing. Whenever any repair work is performed on the structure, fittings of a pressure vessel such as boilers, or whenever repair work involves penetration of ship's hull for weld repair of cracks or similar procedures, the final step in the process must be a test to demonstrate the strength or watertight integrity of the completed repair.

Although it is not necessary that a ship be in drydock to perform repairs to pressure vessel equipment, this kind of work is frequently performed while a ship is drydocked. The usual procedure for hydrostatic testing of pressure vessel equipment starts with a water rinse of the inside walls. The quality of water used depends on the type of equipment. Obviously, non-potable water is not permitted to enter a potable water system. Next, the equipment is filled with water of appropriate quality. Air is applied at test pressure and the equipment examined for leaks. The rinse and test water might be discharged to the drydock but is more likely to be dumped to a holding tank on the ship for later use.

When repairs involving penetration of the hull of ship are performed, the watertight integrity of the completed repair is usually tested in two ways. The first and preliminary method is to apply a stream from a high pressure fire hose on the repaired area while examining the other side for leaks. The final method of testing is performed as a part of the undocking cycle. When the water level reaches a point just prior to floating the ship off of the blocks flooding or sinking is stopped while a thorough inspection for leaks is made inside the ship with particular attention to repaired areas.

PROCESS WASTE CHARACTERIZATION

Ship Originating Wastes

When a ship is drydocked, the quantity of wastewater generated depends upon the expected length of stay in dock and upon specific operations being performed on the ship during the docking cycle. Generally, ships drydocked for short periods and minor repairs operate as if they are berthed at a pier. They require potable and non-potable water and generate wastewater. On other occasions when ships are drydocked for extensive overhaul, they may use little or no water. At the beginning of the docking period, the consumption of water for such purposes as cooling is at its peak. As systems that use water are shut down, water use decreases. A ship undergoing maintenance on its non-potable water system or with its crew disembarked may use no water.

After the dock is dewatered, threaded studs are spot-welded onto the ship's hull, and metal scupper boxes are bolted on at each water discharge location. Soil chutes then are hoseclamped onto the scupper boxes and suspended from the hull. Soil chutes are flexible hoses usually made of rubber-coated nylon or canvas. The lower end of each soil chute is fastened to the appropriate disposal system; for example, cooling water to dock overboard discharge systems. Enough slack is left in the chute so it can be pushed aside if it interferes with rolling equipment. If soil chutes are properly maintained, this system is an effective means of segregating and carrying away ship's wastewater. It would be desirable for the industry to adopt a uniform standard for hose connections so as to eliminate connection leakage.

Cooling Water. As mentioned in the paragraph on Cooling Water, except for a slight temperature increase, non-contact cooling water is discharged from the ship into the drydock in essentially the same condition as supplied from the drydock non-potable water main. Reference 5 reports the following measurements taken at one West Coast facility: nonpotable water supplied at 55°F; non-contact cooling water discharged at 58°F; drainage sump temperature measured at 60°F; and groundwater infiltration, in comparable volume to the cooling water discharge, at 70°F.

Boiler Water. When ship's boilers are to be out of service for short periods, the preferred practice is to keep them completely full of very pure water. Under these conditions, there is no discharge. In some cases, during maintenance or repair work performed on the boiler while a ship is in drydock, it may be necessary to pump the water out of the boiler. This one-time discharge will be slightly alkaline and contain a mixed sludge made up of phosphate and carbonate. The volume of this one-time discharge is approximately twice the steaming capacity of the boiler.

Bilge Discharges. Pumping oily wastewater overboard from bilges is prohibited by Coast Guard Regulations. If an accidental discharge should occur, it is treated as an oil spill within the drydock and clean up is performed before discharge to ambient waters. If an oil spill occurs during flooding or dewatering operations, the operation is stopped until the oil spill is cleaned up.

Other. Although there are other discharges from the ship, such as wastes from the cleaning of tanks and voids, they are generated by drydock industrial activity rather than ship operations and are therefore discussed in Hull Cleaning Waste below.

Dock Originating Wastes

Hull Cleaning Waste. Several methods are used to remove paint, rust, and marine growth, such as barnacles and algae, from the metal surfaces of ship hulls. In all types of surface preparation, the old paint, rust, and marine organisms are found mixed in the spent blasting media. The surface preparation methods are dry abrasive blasting, hydroblasting, wet blasting, water cone blasting, and chemical paint stripping. Surface preparation methods, other than dry blasting, are not common in the industry. Hydroblasting is being tried at three of the shipyards contacted. Wet blasting and water cone blasting is confined principally to Navy ships having special coatings. Chemical paint stripping is rare and is used only on small, localized areas made of more delicate materials. Each method is explained in greater detail below.

Dry abrasive blasting (sandblasting, grit blasting), is the most common method of surface preparation. This method is used in varying degrees by 95 percent of shipyards contacted. When employed, spent abrasive is the principal source of solids in the drydock discharge. Particle sizes of the used grit range from fine dust to whole bits of abrasive, approximately one-eighth inch in diameter. Some of the spent grit falls directly into drainage gutters, especially if a ship is large and the hull sits over the drains. The potential also exists for the abrasive to be washed into the drains from storm runoff, shipboard wastewaters dumped on the dock, hosing, seepage, or other sources of water. The spent grit is, for the most part, settleable.

Sometimes, sand is used as the abrasive, instead of utility slag or copper slag. Delicate equipment, such as sonar domes, are occasionally sand blasted. Rare aluminum-clad hulls are often blasted with sand instead of grit to minimize metal erosion during blasting. One problem with using sand instead of slag is the airborne particulates which are high in silica. The major water pollution problem from sand usage is the possible discharge of solids in the waste stream.

The major pollution problem from hydroblasting (Reference 1) is that the volumes of water used increase the potential that the paint and grit will be flushed into the drainage discharge. Any spilled oil or solvents used elsewhere might be washed into drainage gutters. Since oxidation of the surface of the hull of the ship will prevent a good bond between the fresh paint and metal, rust inhibitors, which contain compounds such as sodium nitrite and diammonium phosphate, are used. (In fact, dry grit blasting is not performed during rainfall so that metal will not rust during or after blasting). Antifreeze may be added to the spray. This will be discharged into the wastewater streams along with the blasting water. Hydroblasting is not preferred by ship repair facilities, because the resulting surface obtained is not as suitable for paint adhesion as the surface obtained by dry grit blasting.

Wet blasting uses a mixture of grit and water. The water acts as the propulsion medium. The solids discharge potential, which is characteristic of dry grit blasting, exists as well as the aforementioned problems of hydroblasting.

Paint may be chemically stripped, rather than blasted, from more delicate apparatus such as sonar domes, antennas and deck machinery. Small articles may be dipped in some yards. Chemical paint stripping was not reported as being used in drydocks by any of the shipyards contacted or visited.

Spent Paint, Rust, and Marine Organisms. Spent paint containing the priority pollutants copper, zinc, chromium, and lead, along with iron oxides and marine organisms are removed from the ships during blasting. The paint contributes to the solid load in the waste stream as well as being subject to contact with stormwater, flooding waters, hose water, and water spills. Additionally, it can be washed, pushed, or blown into uncovered drains.

Antifouling paints are of particular concern. Toxic constituents, such as copper or organotin compounds are used in these paint formulations. Rust and marine growth removed from the sides of the ship may increase quantities of solids in the waste stream.

Fresh Paints and Solvents. Fresh paints contain a variety of metals, such as copper, zinc, chromium and lead, as well as hydrocarbons which are not present in the used paint removed from the ship's hull. Solvents generally are hydrocarbon based. Paints and solvents may be washed into drains; occasionally they are mixed directly over drains with spillage falling into the drains. Overspray from the painting operation is estimated to be between one and two percent. Paint was observed floating in discharge streams at one facility visited. Organotin paint applications were not observed in any of the shipyard visits.

Generally two types of paints are used on ship's hulls: antifouling and anticorrosive. Antifouling paints are toxic to prevent the growth of marine organisms. Cuprous oxide based paints have been used for this purpose for many years. Increased attention has been recently given to the use of organotin antifouling paints. Although the effects of organotin are not well documented, these compounds are reported to be more effective antifoulants than copper based paints, and require a lower percentage of toxic constituents.

There is a trend toward epoxy-based anticorrosive paints replacing vinyl and vinyl-lead based coatings. Pigment materials such as lampblack, red-iron-oxide, and titanium dioxide are added to these paints. Anticorrosive additives are included in epoxy-based or vinyl base paints, usually in the form of zinc dust.

Grease and Oils. The major source of grease and oils is fuel oils and lubricants spilled on drydock floors. Spills most frequently occur when fuel and oils are transferred. Leaky hoses and connections, overflow of containers, and general carelessness contribute to spillage. When stripping fuel tanks, compartments, and when machinery is repaired, or a tank ruptures, oil and grease pollution potential increases. Spills can occur during refilling of fuel tanks at the conclusion of the drydock operations. It is reported that spills over 100 gallons are rare.

Stormwater Runoff. Stormwater is a totally uncontrollable source of wastewater in drydocks. No method of confining rainfall within the dock exists. Channels have been used to direct the water from the dock floor. The major contribution of stormwater to wastewater loads is to increase the quantity of discharge. When heavy and sustained rainfalls occur, stormwater may transport solids to the drains. Some drydocks located in dry climates have essentially no problems due to rainwater.

Dock and Gate Seepage. Another source of wastewater is leakage around the caisson gate of graving docks. This flow of harbor water into the dock can be caused by deterioration of the gate seals or by large pieces of refuse being trapped between the gate and the dock when the caisson is replaced before dewatering. This water flows across the floor and into the drainage system. Some graving docks are designed to allow relief of hydrostatic groundwater pressures through the sidewalls and floor. Relief waters also flow across the floor and into the drain system.

In some dock designs this water is isolated from the dock floor via dams and drains and is channeled directly into the drainage trenches. Flows approaching 100 gal/minute are not uncommon. Floor originating relief waters commonly flow across the dock basin and into the drainage system.

Cleaning Waste. Detergents are used to clean water tanks, bilges, and fuel tanks. The detergents are combined with diesel oil in a one to ten ratio. After cleaning, tanks are rinsed with hot water. This process is a source of oil and grease as well as nitrogen and phosphorus compounds.

On rare occasions, delicate equipment, such as antennas and sonar domes, may be cleaned with detergents prior to painting.

Trash. Cans, paper, bottles, rags, welding rods, scrap metal, and pieces of wood are examples of trash found on a drydock floor prior to flooding. During dewatering, some of these wastes may be flushed out of the docks if they have not been removed.

QUANTITATIVE DATA

During the past several years, monitoring programs have been conducted at several shipyards. Some of the studies were performed by the shipyards while others were conducted by the government. Effluents from two shipyards were sampled for this document and the results of all of these studies are compared in this section. Additionally, leaching studies are analyzed as well as the results of a sieve analysis of abrasive collected at one shipyard. Also included in this section is a discussion of the difficulties and limitations of effectively monitoring shipyard effluents.

Sampling Results

Tables V-2 through V-10 indicate ranges and medians of results obtained during various sampling programs at shipyards A, B and D. Tables V-7 and V-10 combine the results of all data from Shipyards A and D respectively according to different aspects of the effluent discharge.

Table V-2, for Shipyard A is derived from NPDES monitoring conducted by shipyard personnel. A monthly grab sample of the harbor water was obtained at the time of flooding. While a ship was docked, multi-day composites were collected at drainage pump discharges.

Several sets of data exist for Shipyard B. Both shipyard and EPA test results of the same sampling program are summarized (Tables V-3 and V-4). This monitoring occurred during research for the Denver Rationale (Reference 2). Major differences in results are probably due to variations in laboratory techniques. For example, chromium levels found in the EPA results of the split sample are much higher than shipyard findings. This is due to the use by EPA of a glass fiber filter and a Whatman #1 paper filter during sample preparation. Additionally, limits on the accuracy of the testing methods may

explain discrepancies such as higher values for dissolved solids than the corresponding total solids.

Heavy blasting and extensive painting of the docked vessel occurred during the sampling period. Because the purpose of these tests was to prepare the Denver study (Reference 5), and was prior to the issuance of NPDES permits, extensive clean up was not dictated.

Grab samples were collected and composited during initial and final flooding and dewatering, a total of four composited samples. Also, two sequential samplers programmed to draw one sample per hour were used to gain composited daily drainage samples.

NPDES permit monitoring data on dock drainage was available for a thirteen-month period beginning February 1975. The shipyard initiated clean-up practices only during the final month, February 1976. The drainage pump discharge was sampled once per month by yard personnel. Two or three grab samples were taken during a pump cycle and composited (see Table V-5).

Hittman Associates, under contract to EPA, conducted a sampling study in April 1976. Grab samples of the harbor water were collected prior to initial flooding and of initial and final flooded docks. Also, a grab sample was obtained at every two-foot drop in the water level during the initial and final dewaterings. These samples were then composited. Additionally, combined samples were collected and documented during drainage pump cycles throughout the monitoring period. Table V-6 presents the results of these tests.

During sampling at shipyard B, a "very light sand sweep" (32 to 35 tons of grit) of the docked ship, an ore carrier, took place, followed by anticorrosive touch-up painting, and application of antifouling paint. The hull was blasted to the light load line only. Hoses were used to transport most of the shipboard waters to drain channels. At times, cooling water fell directly on the dock floor. Clean up, using manual shovels and front end loaders, took place just prior to flooding and undocking of the ship.

Comparison of the various test results presents few contradictions. In nearly all cases, the minimum and median values were consistent. On rare occasions, high values did differ considerably. Table V-7 composites the data on Shipyard B. Regardless of the extent of painting, effluent levels remain constant. There is no apparent significant change in Shipyard B's NPDES monitoring data during, before, and after clean-up procedures were initiated. It is, therefore, concluded that the nature of the discharge is not conducive to numerical monitoring.

Data for Shipyard D include both NPDES monitoring for 1975 (Table V-8) and sampling from May 1976 conducted for EPA (Table V-9). Shipyard personnel sampled during the second or third week of each month. The date was chosen and sampling occurred regardless of shipyard activity or weather conditions. Two samples were collected from each drain discharge, separately composited, and reported to fulfill NPDES permit requirements.

The May 1976 sampling thoroughly covered the docking procedure, including drainage discharges, regularly for ten days until the dock had been cleaned. Manual shoveling and sweeping, use of front loaders, and occasional hosing were performed to clean up 150 tons of spent abrasive used during the blasting to bare metal of the complete hull of a medium-sized Navy ship. Use of a closed cycle side blaster on about 25 percent of the ship's hull limited the abrasive tonnage. Anticorrosive paint was then applied immediately to the ship's hull. Antifouling paints were not applied during this sampling period.

The sampling program included samples of the harbor water prior to flooding as well as two additional harbor samples during the monitoring period.

Table V-2. SUMMARY OF NPDES MONITORING AT SHIPYARD A
AUGUST 1975 THROUGH SEPTEMBER 1975

| <u>Parameter</u> | <u>Harbor Water</u> | | <u>Drainage Water</u> | |
|-------------------|---------------------|------------|-----------------------|------------|
| | <u>Range</u> | | <u>Range</u> | |
| | <u>High</u> | <u>Low</u> | <u>High</u> | <u>Low</u> |
| pH | 6.9 | 6.7 | 7.0 | 6.8 |
| Suspended Solids | 9.0 | 6.0 | 10.0 | 10.0 |
| Settleable Solids | <0.1 | <0.1 | 0.1 | <0.1 |
| Oil and Grease | 8.2 | 1.2 | 43.82 | 1.71 |
| Pb _T | <0.05 | <0.04 | <0.05 | <0.04 |
| Pb _D | <0.05 | <0.04 | <0.05 | <0.04 |
| Cr _T | 0.02 | <0.03 | <0.03 | 0.02 |
| Cr _D | 0.03 | <0.02 | <0.03 | 0.01 |
| Cu _T | 0.47 | 0.2 | 0.54 | 0.36 |
| Cu _D | 0.04 | 0.03 | 0.04 | 0.04 |
| Sn _T | <0.7 | <0.4 | <0.7 | <0.4 |
| Sn _D | <0.7 | <0.4 | <0.7 | <0.4 |
| Cd _T | <0.01 | <0.01 | <0.01 | <0.01 |
| Cd _D | <0.01 | <0.01 | <0.01 | <0.01 |
| Zn _T | 0.149 | 0.054 | 0.125 | 0.049 |
| Zn _D | 0.066 | 0.027 | 0.04 | 0.038 |
| As _T | 0.02 | <0.01 | 0.04 | <0.01 |
| As _D | 0.02 | <0.01 | 0.04 | <0.01 |
| Hg _T | 0.0035 | 0.0025 | 0.018 | 0.0002 |
| Hg _D | 0.0007 | 0.0004 | 0.0005 | 0.0004 |

All values except pH are in mg/l.

Table V-3. SUMMARY OF SHIPYARD TEST RESULTS
OF EPA/SHIPYARD MONITORING AT GD #B-3 AT SHIPYARD B
MAY 1974

| Parameter | Initial Fill | Initial Dewatering | Drainage Discharge Range | | | Final Fill | Final Dewatering |
|--|-----------------|-----------------------|-----------------------------|---------|---------|---------------|---------------------|
| | Value | Value | High | Low | Median | Value | Value |
| pH | 7.1 | 7.1 | 7.7 | 7.2 | 7.5 | 7.9 | 7.7 |
| Suspended Solids | 30.0 | 35.0 | 19,312.0 | 14.0 | 0.49 | 85.0 | 44.0 |
| Settleable Solids | No Results | No Results | 200.0 | <0.1 | 0.2 | <0.1 | <0.1 |
| PbT | <0.05 | <0.05 | 13.0 | <0.05 | 0.21 | 0.075 | <0.05 |
| PbD | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| CrT | 0.61 | 0.61 | 0.50 | <0.25 | 0.34 | <0.025 | <0.025 |
| CrD | 0.45 | 0.45 | 0.79 | <0.25 | 0.56 | <0.025 | <0.025 |
| CuT | <0.1 | <0.1 | 60.0 | <0.1 | 0.34 | <0.25 | <0.25 |
| CuD | <0.1 | <0.1 | <0.25 | <0.1 | <0.1 | <0.25 | <0.25 |
| SnT | 0.11 | 0.11 | 0.204 | <0.1 | <0.1 | <0.1 | <0.1 |
| SnD | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| CdT | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| CdD | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| ZnT | <0.1 | <0.1 | 4.7 | 0.17 | 0.42 | 0.23 | <0.1 |
| ZnD | <0.1 | <0.1 | 0.15 | <0.1 | 0.11 | <0.1 | <0.1 |
| AsT | <0.02 | <0.02 | 0.19 | <0.02 | <0.02 | 0.15 | 0.12 |
| AsD | <0.02 | <0.02 | 0.15 | <0.02 | <0.02 | 0.09 | 0.062 |
| HgT | <0.0025 | <0.0025 | 0.056 | <0.0025 | 0.0035 | 0.0088 | <0.0025 |
| HgD | <0.0025 | <0.0025 | <0.0025 | <0.0025 | <0.0025 | <0.0025 | <0.0025 |
| FeT | 1.42 | 1.42 | 1,250.0 | 1.8 | 5.5 | 4.2 | 1.5 |
| FeD | <0.1 | <0.1 | 0.16 | <0.1 | <0.1 | <0.1 | <0.1 |
| Flow (m ³ /day) | | | (579.2) | (344.5) | (344.5) | | |
| Flow (gal/day) | | | 153,000 | 91,000 | 97,000 | | |
| Volume of flooded drydock = 1.1 x 10 ⁵ m ³ (28.6 x 10 ⁶ gallons). | | | | | | | |
| All values except pH are in mg/l. | | | | | | | |

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Table V-4. SUMMARY OF EPA TESTING OF
EPA/SHIPYARD MONITORING OF GD #B-3 AT SHIPYARD B
MAY 1974

| <u>Parameter</u> | <u>Initial</u> <u>Fill</u> | <u>Initial</u> <u>Dewatering</u> | <u>Drainage Discharge</u> <u>Range</u> | | | <u>Final</u> <u>Fill</u> | <u>Final</u> <u>Dewatering</u> |
|----------------------------|-------------------------------|-------------------------------------|---|------------|---------------|-----------------------------|-----------------------------------|
| | <u>Value</u> | <u>Value</u> | <u>High</u> | <u>Low</u> | <u>Median</u> | <u>Value</u> | <u>Value</u> |
| Suspended Solids | 2.0 | 2.0 | 20.0 | 2.0 | 6.0 | 6.0 | 3.0 |
| Pb _T | <0.01 | <0.01 | 13.0 | <0.01 | 0.11 | 0.2 | <0.01 |
| Pb _D | <0.01 | <0.01 | 1.2 | <0.1 | <0.1 | <0.01 | 0.01 |
| Cr _T | 0.02 | 0.02 | 1.0 | 0.02 | 0.02 | 0.04 | 0.04 |
| Cr _D | 0.03 | 0.02 | 0.12 | 0.01 | 0.02 | 0.03 | 0.04 |
| Cu _T | 0.06 | 0.07 | 29.0 | 0.1 | 0.25 | 0.13 | 0.06 |
| Cu _D | 0.03 | 0.08 | 4.5 | 0.06 | 0.15 | 0.08 | 0.11 |
| Sn _T | 5.0 | 5.0 | 4.0 | <0.2 | 2.0 | | |
| Sn _D | 5.0 | 4.0 | 3.0 | <0.2 | 2.0 | | |
| Cd _T | 0.05 | 0.05 | 0.09 | 0.01 | 0.03 | 0.05 | 0.07 |
| Cd _D | 0.07 | 0.05 | 0.05 | 0.02 | 0.03 | 0.04 | 0.05 |
| Zn _T | 11.0 | 0.11 | 39.0 | 0.24 | 0.27 | 0.5 | 0.32 |
| Zn _D | 12.0 | 0.14 | 4.1 | 0.16 | 0.26 | 0.12 | 0.14 |
| Hq _T | <0.0001 | <0.0001 | 0.0003 | <0.0001 | 0.0001 | <0.0001 | <0.0001 |
| Hg _D | <0.0001 | <0.0001 | 0.0001 | <0.0001 | <0.0001 | <0.0001 | <0.0001 |
| Flow (m ³ /day) | | | 54.5 | 34.1 | 40.0 | | |
| (gal/day) | | | 144,000 | 90,000 | 95,000 | | |

Approximate volume of filled drydock = 1.1×10^6 m³ (28.6 x 10⁶ gallons).
All values except pH and flow are in mg/l.

Table V-5. SUMMARY OF NPDES MONITORING OF
DRAINAGE DISCHARGE OF SHIPYARD B
FEBRUARY 1975 THROUGH FEBRUARY 1976

| | GD #B-3 and #B-6 | | | GD #B-5 and #B-7 | | | GD #B-1 and #B-4 | | |
|----------------------------|------------------|---------|---------|------------------|---------|---------|------------------|-----------|-----------|
| | Range | | | Range | | | Range | | |
| | High | Low | Median | High | Low | Median | High | Low | Median |
| pH | 7.9 | 7.3 | 7.6 | 8.3 | 7.5 | 7.8 | 8.8 | 7.3 | 7.9 |
| Suspended Solids | 62.3 | 16.6 | 55.1 | 120.0 | 3.6 | 56.0 | 61.5 | 2.8 | 23.0 |
| Settleable Solids | 3.0 | <0.1 | 0.1 | 0.2 | <0.1 | 0.1 | 0.3 | <0.1 | <0.1 |
| Oil and Grease | 6.3 | <0.1 | 1.3 | 5.6 | 0.65 | 1.2 | 2.8 | 0.22 | 0.6 |
| Pb _T | 0.64 | <0.1 | <0.1 | 0.27 | <0.1 | <0.1 | 0.19 | <0.1 | <0.1 |
| Pb _D | <0.1 | <0.1 | <0.1 | 0.14 | <0.1 | <0.1 | 0.14 | <0.1 | <0.1 |
| Cr _T | 0.18 | <0.1 | <0.1 | 0.13 | <0.1 | <0.1 | 0.14 | <0.1 | <0.1 |
| Cr _D | 0.12 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Cu _T | 1.2 | 0.1 | 0.15 | 0.75 | <0.1 | 0.11 | 0.33 | <0.1 | 0.12 |
| Cu _D | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Sn _T | <0.1 | <0.1 | <0.1 | 0.21 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Sn _D | <0.1 | <0.1 | <0.1 | 0.11 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Cd _T | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Cd _D | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Zn _T | 2.05 | 0.29 | 0.33 | 0.85 | 0.13 | 0.3 | 0.18 | <0.1 | 0.11 |
| Zn _D | 0.13 | <0.1 | 0.16 | 0.21 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| As _T | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| As _D | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Hq _T | <0.0025 | <0.0025 | <0.0025 | <0.0025 | <0.0025 | <0.0025 | <0.0025 | <0.0025 | <0.0025 |
| Hq _D | <0.0025 | <0.0025 | <0.0025 | <0.0025 | <0.0025 | <0.0025 | <0.0025 | <0.0025 | <0.0025 |
| Flow (m ³ /day) | 5,300.0 | 2,044.1 | 3,573.4 | 4,542.7 | 1,135.6 | 2,649.6 | 8,327.9 | 4,921.0 | 7,573.8 |
| (gal/day) | 1,400,000 | 540,000 | 930,000 | 1,200,000 | 300,000 | 700,000 | 2,200,000 | 1,300,000 | 2,000,000 |
| Number of Samples | 13 | | | 13 | | | 13 | | |

All values except pH and flow are in mg/l.

Table V-6. SUMMARY OF CONTRACTOR'S
MONITORING AT SHIPYARD B
APRIL 1976

| Parameter | Harbor | Initial | Initial | Drainage Discharge | | | Final | Final |
|----------------------------|--------|---------|------------|--------------------|--------|---------|-------|------------|
| | Water | Fill | Dewatering | Range | | | Fill | Dewatering |
| | Value | Value | Value | High | Low | Median | Value | Value |
| pH | 7.9 | 8.1 | | 8.0 | 7.7 | 7.8 | 7.8 | 7.8 |
| Suspended Solids | 12.0 | 41.0 | 43.0 | 68.0 | 13.0 | 24.0 | 26.0 | 41.9 |
| Settleable Solids | 0.0 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 0.0 | TRACE |
| Oil and Grease | <5.0 | <5.0 | <5.0 | 9.3 | <5.0 | 5.0 | 5.3 | <5.0 |
| PbT | 0.26 | 0.25 | 0.39 | 0.37 | 0.2 | 0.31 | 0.25 | 0.31 |
| PbD | 0.26 | 0.25 | 0.16 | 0.23 | 0.16 | 0.19 | 0.25 | 0.31 |
| CrT | <0.1 | <0.1 | <0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| CrD | <0.1 | <0.1 | <0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| CuT | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| CuD | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| SnT | <2.0 | <2.0 | 2.0 | 4.0 | <2.0 | 3.0 | 3.0 | <2.0 |
| SnD | <2.0 | <2.0 | 2.0 | 3.0 | <2.0 | <2.0 | 2.0 | <2.0 |
| CdT | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 |
| CdD | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 |
| ZnT | <0.02 | <0.02 | <0.2 | 4.0 | <0.02 | 0.3 | 0.1 | 0.5 |
| ZnD | <0.02 | <0.02 | <0.02 | 0.1 | <0.02 | 0.02 | 0.1 | 0.1 |
| MnT | <0.06 | 0.1 | 0.1 | 0.2 | 0.06 | 0.1 | 0.06 | 0.1 |
| MnD | <0.06 | 0.06 | 0.06 | 0.1 | <0.06 | 0.06 | 0.06 | 0.1 |
| AsT | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 |
| AsD | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 |
| HgT | 0.0031 | 0.0027 | 0.0036 | 0.0021 | 0.0012 | 0.0015 | 0.001 | 0.0017 |
| HgD | 0.0031 | 0.0027 | 0.0008 | 0.0021 | 0.0011 | 0.0015 | 0.001 | 0.0017 |
| NiT | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 |
| NiD | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 |
| AlT | <1.0 | <1.0 | <1.0 | 1.6 | <1.0 | <1.0 | <1.0 | <1.0 |
| AlD | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| FeT | 0.3 | 1.0 | 1.2 | 2.6 | 0.4 | 1.1 | 1.1 | 0.8 |
| FeD | <0.1 | <0.1 | <0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Flow (m ³ /day) | | | | | | 3,028.3 | | |
| (gal/day) | | | | | | 800,000 | | |

Volume of filled drydock = 8.3×10^6 m³ (22×10^6 gallons).
All values except pH and flow are in mg/l.

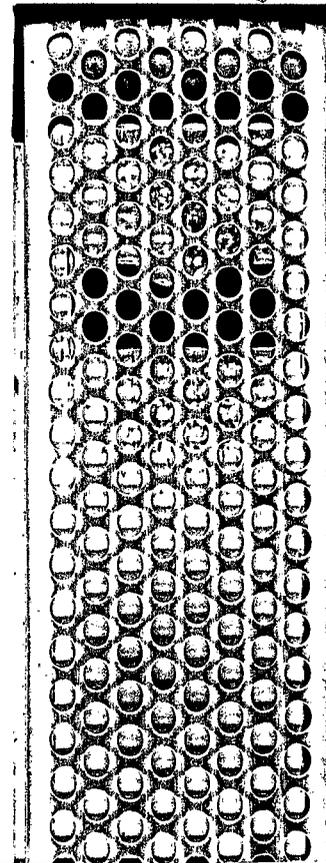
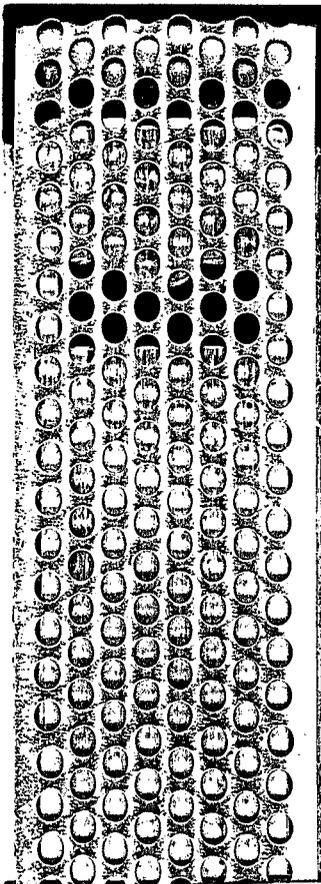


Table V-5. SUMMARY OF NPDES MONITORING OF
DRAINAGE DISCHARGE OF SHIPYARD B
FEBRUARY 1975 THROUGH FEBRUARY 1976

| <u>GD #B-3 and #B-6</u> | | | <u>GD #B-5 and #B-7</u> | | | <u>GD #B-1 and #B-4</u> | | |
|-------------------------|------------|---------------|-------------------------|------------|---------------|-------------------------|------------|---------------|
| <u>Range</u> | | | <u>Range</u> | | | <u>Range</u> | | |
| <u>High</u> | <u>Low</u> | <u>Median</u> | <u>High</u> | <u>Low</u> | <u>Median</u> | <u>High</u> | <u>Low</u> | <u>Median</u> |
| 7.9 | 7.3 | 7.6 | 8.3 | 7.5 | 7.8 | 8.8 | 7.3 | 7.9 |

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Table V-6. SUMMARY OF CONTRACTOR'S
MONITORING AT SHIPYARD B
APRIL 1976

| Parameter | Harbor Water | Initial Fill | Initial Dewatering | Drainage Discharge Range | | | Final Fill | Final Dewatering |
|---|--------------|--------------|--------------------|--------------------------|--------|--------------------|------------|------------------|
| | Value | Value | Value | High | Low | Median | Value | Value |
| pH | 7.9 | 8.1 | | 8.0 | 7.7 | 7.8 | 7.8 | 7.8 |
| Suspended Solids | 12.0 | 41.0 | 43.0 | 68.0 | 13.0 | 24.0 | 26.0 | 41.9 |
| Settleable Solids | 0.0 | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | 0.0 | TRACE |
| Oil and Grease | <5.0 | <5.0 | <5.0 | 9.3 | <5.0 | 5.0 | 5.3 | <5.0 |
| PbT | 0.26 | 0.25 | 0.39 | 0.37 | 0.2 | 0.31 | 0.25 | 0.31 |
| PbD | 0.26 | 0.25 | 0.16 | 0.23 | 0.16 | 0.19 | 0.25 | 0.31 |
| CrT | <0.1 | <0.1 | <0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| CrD | <0.1 | <0.1 | <0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| CuT | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| CuD | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| SnT | <2.0 | <2.0 | 2.0 | 4.0 | <2.0 | 3.0 | 3.0 | <2.0 |
| SnD | <2.0 | <2.0 | 2.0 | 3.0 | <2.0 | <2.0 | 2.0 | <2.0 |
| CdT | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 |
| CdD | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 |
| ZnT | <0.02 | <0.02 | <0.2 | 4.0 | <0.02 | 0.3 | 0.1 | 0.5 |
| ZnD | <0.02 | <0.02 | <0.02 | 0.1 | <0.02 | 0.02 | 0.1 | 0.1 |
| MnT | <0.06 | 0.1 | 0.1 | 0.2 | 0.06 | 0.1 | 0.06 | 0.1 |
| MnD | <0.06 | 0.06 | 0.06 | 0.1 | <0.06 | 0.06 | 0.06 | 0.1 |
| AsT | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 |
| AsD | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 |
| HqT | 0.0031 | 0.0027 | 0.0036 | 0.0021 | 0.0012 | 0.0015 | 0.001 | 0.0017 |
| HqD | 0.0031 | 0.0027 | 0.0008 | 0.0021 | 0.0011 | 0.0015 | 0.001 | 0.0017 |
| NiT | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 |
| NiD | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 |
| AlT | <1.0 | <1.0 | <1.0 | 1.6 | <1.0 | <1.0 | <1.0 | <1.0 |
| AlD | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| FeT | 0.3 | 1.0 | 1.2 | 2.6 | 0.4 | 1.1 | 1.1 | 0.9 |
| FeD | <0.1 | <0.1 | <0.1 | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Flow (m ³ /day) (gal/day) | | | | | | 3,028.3 800,000 | | |

Volume of filled drydock = 8.3 x 10⁶ m³ (22 x 10⁶ gallons).
All values except pH and flow are in mg/l.

Table V-7 SUMMARY OF ALL MONITORING
AT SHIPYARD 8

| Parameter | Initial fill | | | Initial Dewatering | | | Drainage Discharge | | | Final fill | | | Final Dewatering | | |
|-------------------|--------------|---------|---------|--------------------|---------|---------|--------------------|---------|----------|------------|---------|--------|------------------|---------|--------|
| | High | Low | Median | High | Low | Median | High | Low | Median | High | Low | Median | High | Low | Median |
| pH | 8.1 | 7.1 | (2) | 7.1 | | (1) | 8.0 | 7.2 | 7.7 | 7.9 | 7.8 | (2) | 7.8 | 7.7 | (1) |
| Suspended Solids | 41.0 | 2.0 | | 43.0 | 2.0 | 35.0 | 19,312.0 | 2.0 | 36.5 | 26.0 | 6.0 | 0.5 | 44.0 | 41.0 | 3.0 |
| Settleable Solids | 0.1 | 0.0 | (2) | 0.0 | | (1) | 200.0 | 0.0 | < 0.1(3) | <0.1 | 0.0 | (2) | 41.0 | <0.1 | (2) |
| Oil & Grease | 45.0 | | (1) | 5.0 | | (1) | 61.0 | <0.1 | 1.2(2) | <0.1 | 0.0 | (1) | <5.0 | <0.1 | (1) |
| PbT | 0.25 | <0.01 | <0.05 | 0.39 | <0.01 | <0.05 | 13.0 | <0.05 | <0.1 | 5.3 | <0.25 | 0.02 | 0.075 | 0.31 | <0.01 |
| PbD | 0.25 | <0.01 | <0.05 | 0.16 | <0.01 | <0.05 | 1.2 | 0.03 | <0.1 | <0.25 | <0.01 | <0.05 | 0.31 | 0.01 | <0.05 |
| CrT | 0.61 | 0.02 | <0.1 | 0.61 | 0.02 | <0.1 | 1.0 | <0.025 | <0.1 | <0.01 | <0.025 | <0.05 | 0.04 | <0.01 | 0.025 |
| CrD | 0.45 | 0.03 | <0.1 | 0.45 | 0.02 | <0.1 | 0.79 | 0.01 | <0.1 | <0.01 | <0.025 | 0.04 | <0.01 | 0.025 | 0.04 |
| CuT | <0.1 | 0.06 | <0.1 | <0.1 | 0.07 | <0.1 | 60.0 | <0.1 | <0.1 | <0.01 | <0.025 | 0.04 | <0.01 | 0.925 | 0.04 |
| CuD | <0.1 | 0.03 | <0.1 | <0.1 | 0.08 | <0.1 | 4.5 | 0.06 | <0.1 | <0.25 | <0.1 | 0.13 | <0.25 | 0.06 | <0.1 |
| SnT | 5.0 | 0.11 | <2.0 | 5.0 | 0.11 | 2.0 | 5.0 | <0.1 | <0.1 | <0.25 | <0.1 | 0.08 | <0.25 | <0.1 | 0.11 |
| SnD | 5.0 | <0.1 | <2.0 | 4.0 | <0.1 | 2.0 | 3.0 | <0.1 | <0.1 | 3.0 | <0.1 | (2) | 6.0 | 0.1 | <2.0 |
| CdT | 0.05 | 0.03 | <0.05 | 0.05 | 0.03 | <0.05 | <0.1 | 0.01 | <0.1 | 2.0 | <0.1 | (2) | 6.0 | 0.1 | <2.0 |
| CdD | 0.07 | <0.03 | <0.05 | 0.05 | 0.03 | <0.05 | <0.1 | 0.02 | <0.1 | 0.05 | 0.03 | <0.05 | 0.07 | 0.03 | <0.05 |
| ZnT | 11.0 | <0.02 | <0.1 | 0.11 | <0.02 | <0.1 | 39.0 | <0.02 | 0.26 | <0.05 | 0.03 | 0.04 | 0.05 | 0.03 | <0.05 |
| ZnD | 12.0 | <0.02 | <0.1 | 0.14 | <0.02 | <0.1 | 4.1 | <0.02 | <0.1 | 0.5 | 0.1 | 0.23 | 0.5 | 0.1 | 0.32 |
| MnT | 0.1 | | (1) | 0.1 | | (1) | 0.2 | 0.06 | 0.1(1) | 0.12 | <0.1 | 0.1 | 0.14 | 0.1 | 0.1 |
| MnD | 0.06 | | (1) | 0.06 | | (1) | 0.1 | <0.06 | 0.06(1) | 0.06 | | (1) | 0.1 | | (1) |
| AsT | <0.02 | <0.02 | (2) | <0.02 | <0.02 | (2) | 0.19 | <0.02 | <0.1 | 0.06 | | (2) | 0.12 | <0.02 | (2) |
| AsD | <0.02 | <0.02 | (2) | <0.02 | <0.02 | (2) | 0.15 | <0.02 | <0.1 | 0.15 | | (2) | 0.062 | <0.2 | (2) |
| HgT | 0.0027 | <0.0001 | <0.0025 | 0.0036 | <0.0001 | <0.0025 | 0.056 | <0.0001 | <0.0025 | 0.09 | 40.02 | | 0.062 | <0.2 | (2) |
| HgD | 0.0027 | <0.0001 | <0.0025 | <0.0025 | <0.0001 | 0.0008 | <0.0025 | <0.0001 | <0.0025 | 0.0088 | 40.02 | 0.001 | <0.0025 | <0.0001 | 0.0017 |
| NiT | 40.2 | | (1) | 2.0 | | (1) | <0.2 | <0.0001 | <0.0025 | <0.0025 | <0.0001 | 0.001 | <0.0025 | <0.0001 | 0.0017 |
| NiD | 40.2 | | (1) | 2.0 | | (1) | <0.2 | <0.2 | <0.2 (1) | 0.001 | | (1) | 40.2 | | (1) |
| AlT | <1.0 | | (1) | <1.0 | | (1) | 1.6 | <1.0 | <1.0 (1) | 0.001 | | (1) | <1.0 | | (1) |
| AlD | <1.0 | | (1) | <1.0 | | (1) | <1.0 | <1.0 | <1.0 (1) | <1.0 | | (1) | <1.0 | | (1) |
| FeT | 1.42 | 1.0 | (2) | 1.42 | 1.2 | (2) | 1,250.0 | 1.8 | 5.5 (1) | <1.0 | 4.2 | 1.1 | <1.0 | 1.5 | 0.8 |
| FeD | <0.1 | <0.1 | (2) | 0.1 | <0.1 | (2) | 0.16 | <0.1 | <0.1 (1) | <0.1 | <0.1 | (2) | <0.1 | <0.1 | (2) |
| Number of | | | 3 | | | 3 | | | 4 | | | (2) | | | 3 |

All values except pH are in mg/l.

Numbers in parentheses () indicate number of tests performed if different from "Number of Tests".

Table V-8 SUMMARY OF NPDES MONITORING
OF DRAINAGE DISCHARGES AT SHIPYARD D
JANUARY 1975 THROUGH DECEMBER 1975

| Parameters | Harbor Water | | | GD #D-2 | | | GD #D-3 | | | GD #D-4 | | |
|----------------------------|--------------|-------|--------|---------|---------|---------|---------|-------|--------|---------|---------|---------|
| | High | Low | Median | High | Low | Median | High | Low | Median | High | Low | Median |
| pH | NR | NR | NR | 7.9 | 6.9 | 7.6 | 8.1 | 7.5 | 7.7 | 7.8 | 7.5 | 7.7 |
| Suspended Solids | 19.0 | 1.7 | 5.6 | 20.0 | 4.4 | 9.1 | 22.0 | 3.2 | 10.0 | 32.0 | 3.2 | 16.0 |
| Settleable Solids | NR | NR | NR | 0.3 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 |
| Oil & Grease | NR | NR | NR | 4.0 | 0.0 | 2.0 | 3.4 | 0.0 | 0.2 | 3.8 | 0.0 | 1.3 |
| Pb _T | NR | NR | NR | 0.7 | <0.01 | <0.05 | 0.6 | <0.01 | <0.04 | 0.58 | <0.01 | <0.02 |
| Cr _T | NR | NR | NR | 0.27 | <0.1 | <0.1 | 0.34 | <0.01 | <0.05 | 0.2 | 0.0 | 0.03 |
| Cu _T | 1.4 | <0.05 | 0.12 | 1.2 | <0.05 | 0.21 | 1.6 | 0.07 | 0.25 | 4.1 | 0.1 | 0.27 |
| Sn _T | NR | NR | NR | <1.0 | 0.03 | <0.1 | <1.0 | 0.03 | <0.7 | <1.0 | <0.01 | <0.5 |
| Zn _T | 1.6 | 0.02 | 0.29 | 1.8 | 0.02 | 0.6 | 1.2 | 0.1 | 0.5 | 1.1 | 0.03 | 0.28 |
| Fe _T | 0.39 | <0.01 | 0.07 | 3.2 | 0.02 | 0.39 | 3.0 | 0.13 | 1.0 | 3.0 | 0.13 | 0.91 |
| Flow (m ³ /day) | | | | 1135.6 | 1135.6 | 1135.6 | | | | 473.2 | 473.2 | 473.2 |
| (gal/day) | | | | 300,000 | 300,000 | 300,000 | | | | 125,000 | 125,000 | 125,000 |

All values except pH and flow are in mg/l.

NR = No Result

Table V-9 SUMMARY OF CONTRACTORS
MONITORING OF GD #D-3 SHIPYARD D
MAY 1976

| Parameter | Harbor Water | | Initial Half Filled Dock | | Initial Value | | Initial Value | | Initial Value | | Initial Value | | Drainage Discharge | |
|-------------------|--------------|--------|--------------------------|--------|---------------|-------|---------------|-------|---------------|--------|---------------|--------|--------------------|--------|
| | High | Low | Value | Value | Value | Value | Value | Value | Value | Value | High | Low | Range | Median |
| pH | 9.3 | 8.4 | 8.5 | 8.6 | 8.6 | 8.6 | 8.6 | 8.6 | 8.6 | 9.1 | 7.6 | 8.6 | | |
| Suspended Solids | 200.0 | 6.0 | 88.0 | 44.0 | 44.0 | 106.0 | 106.0 | 106.0 | 106.0 | 166.0 | 20.0 | 74.0 | | |
| Settleable Solids | TRACE | 0.0 | TRACE | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | | |
| Pb | <5.0 | <5.0 | <5.0 | 0.47 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 |
| Cd | 0.57 | 0.36 | 0.57 | 0.43 | 0.47 | 0.47 | 0.47 | 0.47 | 0.47 | 0.57 | 0.33 | 0.43 | | |
| Cu | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | 0.1 | 0.32 | 0.4 | | |
| Zn | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Mn | <0.1 | <0.1 | 0.4 | 0.1 | 0.1 | 0.2 | 0.2 | 0.2 | 0.2 | 1.1 | <0.1 | 0.2 | | |
| Cr | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | 0.3 | <0.1 | <0.1 | <0.1 | <0.1 |
| Ni | 3.4 | <2.0 | <2.0 | <2.0 | <2.0 | <2.0 | <2.0 | <2.0 | <2.0 | 3.7 | <2.0 | <2.0 | <2.0 | <2.0 |
| Ag | 2.1 | <2.0 | <2.0 | <2.0 | <2.0 | <2.0 | <2.0 | <2.0 | <2.0 | 2.0 | <2.0 | <2.0 | <2.0 | <2.0 |
| Co | 0.06 | 0.05 | 0.06 | 0.05 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.06 | <0.03 | 0.04 | | |
| Mg | 0.05 | <0.03 | 0.06 | 0.05 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | <0.03 | 0.04 | | |
| Al | 0.45 | <0.02 | 0.07 | <0.02 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.59 | <0.02 | 0.16 | | |
| Fe | 0.45 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | 0.36 | <0.02 | 0.05 | | |
| Mn | 0.14 | <0.06 | 0.06 | 0.08 | 0.08 | <0.06 | <0.06 | <0.06 | <0.06 | 1.83 | 0.25 | 1.43 | | |
| Mn | 0.1 | <0.06 | <0.06 | <0.06 | <0.06 | <0.06 | <0.06 | <0.06 | <0.06 | 1.79 | 0.21 | 1.4 | | |
| As | 0.05 | <0.02 | 0.08 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | 0.04 | <0.02 | <0.02 | <0.02 | <0.02 |
| As | <0.02 | 0.02 | <0.06 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 |
| Hg | 0.0014 | 0.0013 | 0.0008 | 0.0018 | 0.0018 | 1.6 | 1.6 | 1.6 | 1.6 | 0.0019 | <0.0001 | 0.0001 | <0.0001 | 0.0001 |
| Hg | 0.0014 | 0.0006 | 0.0008 | 0.0012 | 0.0012 | 1.6 | 1.6 | 1.6 | 1.6 | 0.0019 | <0.0001 | 0.0001 | <0.0001 | 0.0001 |
| Ni | 0.36 | 0.24 | 0.2 | 0.21 | 0.21 | 0.23 | 0.23 | 0.23 | 0.23 | 0.35 | <0.2 | <0.2 | <0.2 | <0.2 |
| Ni | 0.36 | 0.24 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | 0.35 | <0.2 | <0.2 | <0.2 | <0.2 |
| Al | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | 1.1 | <1.0 | <1.0 | <1.0 | <1.0 |
| Al | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| Fe | 0.8 | 0.2 | 0.2 | 0.5 | 0.5 | 1.2 | 1.2 | 1.2 | 1.2 | 3.7 | 1.6 | 2.0 | | |
| Fe | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.4 | 0.4 | 0.4 | 0.4 | 2.1 | 0.6 | 0.8 | | |

Flow (m³/day)
(gal/day)

946.4
250,000

Volume of filled drydock = 4.9 x 10⁴ m³ (12 x 10⁶ gallons)

All values except pH are in mg/l

Table V-10 SUMMARY OF ALL HARBOR AND DRAINAGE DISCHARGE MONITORING AT SHIPYARD D

| Parameter | Harbor Water | | | Drainage Discharge | | |
|-------------------|--------------|--------------|----------|--------------------|--------------|----------|
| | High | Range Low | Median | High | Range Low | Median |
| pH | 9.3 | 8.4 | 9.0 | 9.1 | 6.9 | 7.9 (2) |
| Suspended Solids | 200.0 | 1.7 | 6.0 | 166.0 | 3.2 | 17.0 (2) |
| Settleable Solids | TRACE | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 (2) |
| Oil & Grease | <5.0 | <5.0 | <5.0 | <5.0 | 0.0 | 3.2 (2) |
| Pb _T | 0.57 | 0.36 | 0.43 | 0.57 | 0.01 | 0.07 (2) |
| Pb _D | 0.57 | 0.36 | 0.42 | 0.50 | 0.32 | 0.4 |
| Cr _T | 0.1 | <0.1 | <0.1 | 0.27 | <0.01 | <0.1 (2) |
| Cr _D | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Cu _T | 1.4 | <0.05 | 0.12 (2) | 4.1 | 0.03 | 0.2 (2) |
| Cu _D | <0.1 | <0.1 | <0.1 | 0.3 | <0.1 | <0.1 |
| Sn _T | 3.4 | <2.0 | 2.1 | 3.7 | 0.01 | <1.0 |
| Sn _D | 2.1 | <2.0 | <2.0 | 2.9 | <2.0 | <2.0 |
| Cd _T | 0.06 | 0.05 | 0.05 | 0.06 | <0.03 | <0.04 |
| Cd _D | 0.05 | <0.03 | 0.05 | 0.06 | <0.03 | <0.04 |
| Zn _T | 1.6 | <0.02 | 0.19 (2) | 2.0 | 0.02 | 0.28 (2) |
| Zn _D | 0.45 | <0.02 | <0.1 | 0.36 | <0.02 | 0.05 |
| Mn _T | 0.14 | <0.06 | 0.1 | 1.83 | 0.25 | 1.43 |
| Mn _D | 0.1 | <0.06 | 0.07 | 1.79 | 0.21 | 1.4 |
| As _T | 0.05 | <0.02 | <0.02 | 0.04 | <0.02 | <0.02 |
| As _D | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 |
| Hg _T | 0.0014 | 0.0013 | 0.0014 | 0.0019 | <0.0001 | <0.0009 |
| Hg _D | 0.0014 | 0.0006 | 0.0013 | 0.0019 | <0.0001 | 0.0008 |
| Ni _T | 0.36 | 0.24 | 0.36 | 0.35 | <0.2 | <0.2 |
| Ni _D | 0.36 | 0.24 | 0.36 | 0.35 | <0.2 | <0.2 |
| Al _T | <1.0 | <1.0 | <1.0 | 1.1 | <1.0 | <1.0 |
| Al _D | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 | <1.0 |
| Fe _T | 0.39 | <0.01 | 0.07 (2) | 3.7 | 0.02 | 1.3 |
| Fe _D | 0.2 | 0.2 | 0.2 | 2.1 | 0.6 | 0.8 |

All values except pH are in mg/l.

(2) Indicates both contractor and NPDES monitoring.
All other results are only contractor results.

A grab sample of the flooded dock was collected and a composite of samples collected at each two-foot water level drop was made during dewatering. Samples were taken of the drainage water during hosedown following initial dewatering and regularly throughout the monitoring period. Every two minutes during the pumping cycle, samples were drawn and composited.

During the May 1976 sampling program at Shipyard D, the harbor water was actually higher in certain constituents, such as total suspended solids and pH, than in the NPDES tests. No significant increases occurred between corresponding influents and effluents. As in samples at other shipyards, discharge levels tend to be very low with rare "high" values of certain parameters. It could not be established that dockside activities affect discharge levels. As in the case of Shipyards A and B, constituent levels remain constant throughout. Only levels of manganese varied from the harbor water concentrations. In all likelihood, this can be attributed to groundwater infiltration since no other major source of manganese is apparent. The results again lead to the conclusion that the nature of the discharge is not conducive to numerical monitoring.

Several obstacles exist with respect to conducting an accurate sampling program of floating drydocks and/or graving docks. Some of these problems are due to the nature of the operation and drydock design. Other difficulties occur during interpretation of the data.

- o The physical design and operation of a floating drydock is not conducive to conducting an effective sampling program. During submersion of the dock, potential contaminants such as grit and paint might be flushed from the surface of the dock, rather than discharged through a single sampling point such as a pipe or sewer, as in the case with graving docks.

When the dock is submerged, grit, spent paint, oil and grease, and other dockside wastes may be flushed or may float from the dock floor. Any spills, stormwater, or discharges onto the floated dock floors will randomly run off the ends and through scuppers along the sides of the floating drydock. Since there are multiple discharge points, accurate sampling is not feasible.

- o Because only total drainage discharges were monitored on a daily basis, it is difficult to attribute constituents and flows to any individual source or operation. For example, variations in flows and composition of cooling water and degree of hydrostatic relief might occur concurrently with an operation such as blasting or painting. Any alteration in drainage discharge would be difficult to correlate with these activities.

Shipyard D management once attempted to estimate all drydock discharge parameters and levels but were unable to determine the source of some of the contaminants. The problem obviously is complex.

- o Insufficient documentation of sampling programs performed prior to this contract makes interpretation of previous monitoring questionable. By failing to explain what shipyard operations were in progress, weather conditions, floor conditions, and especially analytical procedures, interpretation and comparison of monitoring data is difficult.

- o The lack of a "typical" daily dock operation means that all data obtained is particular to that specific day and is not necessarily representative of the usual drydock discharges. Consequently interpretation of the data is difficult. This restricts determination of sources and establishment of recommendations.

Leaching Studies

Studies of the leachability of the fresh abrasive and spent abrasive and paint were done at several shipyards. The experiments are discussed below.

Leaching Study #1 consisted of an experiment in which 400 grams of spent abrasive collected from a shipyard facility were mixed with a liter of seawater. The combination was shaken intermittently. A 100 ml aliquot was withdrawn after two days one inch below the surface. Another aliquot was withdrawn after eight days. The method of analysis was not defined. The two aliquots produced no difference in concentrations of Cd, Cr, Zn, Cu, and Sn. Only levels of lead showed a significant increase.

The results of leaching Study #2 present markedly different conclusions. These tests performed by EPA indicate that the spent abrasive may actually act as an adsorbent of metals already present in the water. Approximately 100 grams of spent abrasive collected at five different shipyards were each exposed to approximately one liter of seawater from the local bay. An analysis indicated that cadmium, chromium, lead, and tin levels all either remain the same or decreased. Only copper and zinc exhibited any increase in concentration.

Leaching Study #3 resulted in no major change in nickel, zinc, tin, or cadmium. Slight increases in chromium, copper, iron, and lead levels occurred, but mercury concentration was reduced 98 percent.

The data for Leaching Study #4 was much more thorough. Seven spent abrasive samples and two fresh abrasive samples were subjected to a leaching test in seawater. A level of pollutant was determined after exposure of 300 hours and 700 hours. Only lead concentrations markedly increased with each sample. Copper and zinc levels increased significantly on occasions, but otherwise remained constant. Arsenic, cadmium, mercury, and tin concentrations never varied appreciably. Levels of copper, lead, and zinc in the liquid consistently corresponded to the levels in the spent abrasive. Similarly low values of these metals in the liquid samples occurred when the spent abrasive contained lesser quantities of these three elements.

Leaching Study #5 consisted of treating five different samples of grit and river sediment with river water or deionized water. Some of the experiments involved stirring, while others did not. Chromium levels actually showed a slight decrease in value, indicating again the possibility that the abrasive acts in certain cases as an adsorbent. Copper levels changed very little. Data on leachability of zinc was inconclusive since concentrations of zinc increased in some instances and decreased in others.

There are many inconsistencies in the results of the five leaching studies reviewed. Questions which remain about testing procedures and conflicting data indicate that further study would be beneficial. Doubts exist about the reliability of a leaching test done in a small closed container where dilution and circulation are not factors.

Sieve Analyses of Debris

Sieve analyses were conducted on fresh grit and spent paint and abrasive collected by the contractor at Shipyard B. One sample consisted entirely of fresh abrasive, and the second sample containing spent paint and grit was collected from the drydock floor immediately following blasting. The two samples were analyzed using a standard sieve analysis and the results are shown in Table V-11 and V-12.

Table V-11. GRAIN-SIZE ANALYSIS
OF UNSPENT GRIT (SAMPLE 1)

| <u>Sieve</u> | <u>% Retained</u> | <u>% Finer</u> |
|--------------|-------------------|----------------|
| 10 | 15 | 85 |
| 40 | 83 | 2 |
| 60 | 1.8 | .2 |
| 140 | <.1 | <.1 |
| 200 | <.1 | <.1 |
| <200 | <.1 | <.1 |
| | <u>100</u> | |

Average specific gravity = 4.617

Table V-12. GRAIN-SIZE ANALYSIS OF
SPENT GRIT AND SPENT PAINT (SAMPLE 2)

| <u>Sieve</u> | <u>% Retained</u> | <u>% Finer</u> |
|--------------|-------------------|----------------|
| 10 | 10 | 90 |
| 40 | 78 | 12 |
| 60 | 6 | 6 |
| 140 | 3 | 3 |
| 200 | 1 | 2 |
| <200 | 2 | 1 |
| | <u>100</u> | |

Average specific gravity = 4.418

The fresh grit, "Black Beauty," was purchased by the company from power plants. The abrasive is actually the slag collected from coal-fired boilers. The principal constituents are iron, aluminum, and silicon oxides (see Table III-3). The spent grit and paint, which were collected following a "very light sand sweep," contained flakes and particles of antifouling and primer paints and bits of iron oxides. The test results indicate that over 95 percent of the particles in each sample were sand size and were retained in U.S.A. Standard Testing sieves numbered 10, 40, 60, and 140, made by Tyler Equipment Co., with the largest fraction retained in sieve number 40. The unspent grit particles were slightly larger and the facets were sharper and more defined. The specific gravities of the two samples did not differ significantly. These sand-size particles were readily settleable.

SECTION VI

SELECTION OF POLLUTION PARAMETERS

INTRODUCTION

Materials originating from shipbuilding and repair activities which may have significance as potential pollutants have been identified during the course of this study. Although an exhaustive list of materials capable of discharge to waterways could be developed, many of these can be eliminated from consideration. The priority pollutants copper, zinc, chromium, and lead have been identified as being present in shipyard facilities under conditions which can result in their discharge. Compounds of these metals are constituents of fresh paints (Tables III-4 and III-5). They persist in the abrasive blasting debris as components of the spent paint and abrasive. The rationale for selection of constituents as pollution parameters or for rejection of others is presented here.

While numerical guidelines and standards are not being recommended at this time, pollution parameters are being identified for consideration by the users of this document and for further investigation, and use where it may be appropriate.

Factors which have been considered in selecting and rejecting pollution parameters include:

- o The degree of polluttional constituents used and discharged from ship repair and construction operations in graving docks and floating drydocks.
- o The need for preventing the introduction of the constituent into the waterway; and
- o The aesthetic effects of the constituent and the effects on other uses of the water.

A list of constituents which may be subject to discharge from graving docks and from floating drydocks is shown in Table VI-1. Pollution parameters have been selected from this list, and this is discussed in the following sections.

Table VI-1. MATERIALS ORIGINATING FROM DRYDOCKS WHICH MAY BE DISCHARGED TO WATERWAYS

| <u>Constituents</u> | <u>Source</u> | <u>Comments</u> |
|---|---|--|
| Fresh Grit | Spills during transfer and handling | Uncontaminated solid, usually slag, sand, cast iron or steel shot |
| Blasting Debris | Material removed from ships hull during blasting | Spent grit, marine fouling, spent paint, rust, may contain priority pollutants |
| Solid Wastes | Repair and Construction Activities | Scrap metal, welding rods, wood, plastics, trash such as paper and food scraps |
| Fresh Paint | Paint mixing spills, overspray | Overspray may reach dock floor, spills to floor or drains and contains priority pollutants |
| Oil & Grease Fuel | Spills and leakage from ship and equipment, losses during servicing | Can originate either from vessel or from dock activities |
| Oil, Grease and Fuel Contaminated Water | Leakage from tank cleaning and ruptured tanks, bilgewater | May contain detergents used in tank cleaning |
| Solvents, Paint Remover | Paint stripping other than blasting | Not common practice |
| Boiler Water | Vessel boiler | High quality water, usually not discharged |
| Cooling Water | Vessel equipment | Supplied by on-shore source, once-through, non-contact |
| Hydrostatic Leakage | Groundwater leakage into dock | Graving docks only |
| Gate Leakage | Harbor water | Graving docks only |

Materials identified in Table VI-1 may produce other contaminants in water. Their effects are generally measured in terms of parameters such as suspended solids, dissolved solids, BOD and COD, oil and grease, and specific elements or chemical species. Table VI-2 lists specific and nonspecific parameters which are possible pollutants. Analytical methods for monitoring would necessarily include some or all of the items listed in Table VI-2.

Table VI-2. PARAMETERS WHICH MAY BE PRESENT IN WASTEWATER DISCHARGES FROM DRYDOCKS

| <u>Specific Parameters</u> | | <u>Non-Specific Parameters</u> | |
|----------------------------|-------------------|--------------------------------|--|
| <u>Metals</u> | <u>Non-Metals</u> | | |
| Pb Mn | PO ₄ | pH | |
| Cr As | NO ₂ | Total Suspended Solids | |
| Cu Hg | | Settleable Solids | |
| Sn Ni | | Oil and Grease | |
| Cd Al | | | |
| Zn Fe | | | |

RATIONALE FOR THE SELECTION OF POLLUTION PARAMETERS

During the course of this study and the sampling program conducted in support of it, it has become evident that a direct cause and effect relationship between activities and materials in the docking facility and constituents in the wastewater does not always exist. In addition, much of the water purposefully used in drydocking operations is harbor water already containing measurable levels of constituents leached from the drainage area supplying the harbor, discharged from other sources, or naturally present in the water. Because of this, the problem of identifying the origin of these constituents, in the presence of sampling and analytical variations, becomes complex.

In selecting pollution parameters two questions have been considered as vital to the proper inclusion of a constituent in this category. The first of these is, "Are the constituents discharged to the environment"? Second, and equally important is, "Is the constituent present in the ship repair and construction facility in a condition capable of creating a hazardous discharge"? If both of these questions can be answered in the affirmative, the constituent should be

considered a potential pollutant requiring monitoring and possibly necessitating controls.

Referring to Table VI-2, the listed metals all may be constituents of the paint used on hulls. The most commonly used anticorrosive paints contain zinc chromate or lead oxide. Antifouling paints in current use usually incorporate cuprous oxide. The use of arsenic and mercury antifouling paints has been discontinued because of their toxicity. Recently, antifouling paints containing organotin compounds have been introduced into practice. These have the advantage of longer life in service but when removed for repainting, like mercury based paints, can be toxic to workers. Three sources of iron exist in the drydocking facility. Steel scrap and waste metal are major sources. Iron from scrap is initially in the metallic form but air and moisture will rapidly produce a surface coat of rust. The second source is iron oxide contained in the paints. The amount of iron oxide in paint is negligible compared to the other paint components and to exposed steel surfaces found in the drydock area. The third source is metallic iron abraded from ships during abrasive blasting and subsequent potential dissolution into water.

Non-metal constituents are phosphates and nitrites. These are added to water in trace quantities during wet blasting to bare metal. They function as rust inhibitors. Their use is infrequent and total quantities are small.

Non-specific parameters which may ultimately be transported to wastewater are also listed in Table VI-2.

Solids content is measured by total solids, suspended and settleable solids, and dissolved solids. Total solids is the total of the suspended and dissolved components. Most of the suspended solids are spent paint and grit from the blasting operations, but may also include dried fresh paint resulting from overspray and spills. Other sources of solids are metal or metal scale particulates resulting from cutting and cleaning work, slag from arc welding, wood and other organic solids particles, etc., all in small quantities. Dissolved solids may be present due to constituents from spent or fresh paint, solution of iron or alloy metals from scrap steel, and solution of components from virtually any solid coming in contact with water.

A measure of the hydrogen ion concentration of water is pH. As such, it can be altered (from the neutral value of 7) to either acidic or basic values by the effects of dissolved materials added to the water.

Oil and grease are measures of the quantity of organic compounds extractable by hexane. This can include not only oils and greases, but also fuel, solvents, and paint components.

The parameters selected as pollutants potentially released by shipyard activities into wastewaters are listed in Table VI-3. These constituents represent materials which are commonly used in drydocking facilities and hence which have potential for release to ambient waters. Although other parameters listed in Table VI-2 have been rejected as pollutants to be regulated at this time, the sampling and analysis program routinely determined the levels of those as well. The basis for rejection is discussed in the subsection on "Rationale for Rejection of Pollution Parameters."

Table VI-3. POLLUTION PARAMETERS

| <u>Specific Parameters</u> | | <u>Other Metals</u> | <u>Non-Specific Parameters</u> |
|----------------------------|-------------------|---------------------|--------------------------------|
| <u>Priority Pollutants</u> | <u>Non-Metals</u> | | |
| Zn | None | Sn* | Suspended Solids |
| Cu | | | Settleable Solids |
| Pb | | | Oil and Grease |
| Cr | | | pH |

*Only where organotin anti-fouling plants may be used or removed from the hull.

It must be emphasized that one of the great uncertainties in establishing pollution parameters arises from the use of harbor water for most of the shipyard operations. Unlike chemical processing plants, where high quality water is used, input water may vary in constituent concentration from fresh lake and river water to saline ocean water, thus the background content of suspended and dissolved components may mask many of the parameters frequently monitored. The following subsections discuss each of the parameters selected as potential pollutants.

Zinc (Zn)

Occurring abundantly in rocks and ores, zinc is readily refined into a stable pure metal and is used extensively as a metal, an alloy, and a plating material. In addition, zinc salts are also used in paint pigments, dyes, and insecticides. Many of these salts (for example, zinc chloride and zinc sulfate) are highly soluble in water; hence, it is expected that zinc might occur in many industrial wastes. On the other hand, some zinc salts (zinc carbonate, zinc oxide, zinc sulfide) are insoluble in water and, consequently, it is expected that some zinc will precipitate and be removed readily in many natural waters.

In soft water, concentrations of zinc ranging from 0.1 to 1.0 mg/l have been reported to be lethal to fish. Zinc is thought to exert its toxic action by forming insoluble compounds with the mucous that covers the gills, by damage to the gill epithelium, or possibly by acting as an internal poison. The sensitivity of fish to zinc varies with species, age, and condition, as well as with the physical and chemical characteristics of the water. Some acclimatization to the presence of the zinc is possible. It has also been observed that the effects of zinc poisoning may not become apparent immediately so that fish removed from zinc-contaminated to zinc-free water may die as long as 48 hours after the removal. The presence of copper in water may increase the toxicity of zinc to aquatic organisms, while the presence of calcium or hardness may decrease the relative toxicity.

A complex relationship exists between zinc concentrations, dissolved oxygen, pH, temperature, and calcium and magnesium concentrations. Prediction of harmful effects has been less than reliable and controlled studies have not been extensively documented.

Concentrations of zinc in excess of 5 mg/l in public water supply sources cause an undesirable taste which persists through conventional treatment. Zinc can have an adverse effect on man and animals at high concentrations.

Observed values for the distribution of zinc in ocean waters vary widely. The major concern with zinc compounds in marine waters is not one of acute lethal effects, but rather one of the long term sublethal effects of the metallic compounds and complexes. From the point of view of acute lethal effects, invertebrate marine animals seem to be the most sensitive organisms tested.

A variety of freshwater plants tested manifested harmful symptoms at concentrations of 10 mg/l. Zinc sulfate has also been found to be lethal to many plants and it could impair agricultural uses of the water.

Copper (Cu)

Copper is an elemental metal that is sometimes found free in nature and is found in many minerals such as cuprite, malachite, azurite, chalcopyrite, and hornite. Copper is obtained from these ores by smelting, leaching, and electrolysis. Significant industrial uses are in the plating, electrical, plumbing, and heating equipment industries. Copper is also commonly used with other minerals as an insecticide and fungicide.

Traces of copper are found in all forms of plant and animal life, and it is an essential trace element for nutrition. Copper is not considered to be a cumulative systemic poison for humans as it is

readily excreted by the body, but it can cause symptoms of gastroenteritis, with nausea and intestinal irritations, at relatively low dosages. The limiting factor in domestic water supplies is taste. Threshold concentrations for taste have been generally reported in the range of 1.0 to 2.0 mg/l of copper while concentrations of 5 to 7.5 mg/l have made water completely undrinkable. It has been recommended that the copper in public water supply sources not exceed 1 mg/l.

Copper salts cause undesirable color reactions in the food industry and cause pitting when deposited on some other metals such as aluminum and galvanized steel. The textile industry is affected when copper salts are present in water used for processing of fabrics. Irrigation waters containing more than minute quantities of copper can be detrimental to certain crops. The toxicity of copper to aquatic organisms varies significantly, not only with the species, but also with the physical and chemical characteristics of the water, including temperature, hardness, turbidity, and carbon dioxide content. In hard water, the toxicity of copper salts may be reduced by the precipitation of copper carbonate or other insoluble compounds. The sulfates of copper and zinc, and of copper and cadmium are synergistic in their toxic effect on fish.

Copper concentrations less than 1 mg/l have been reported to be toxic, particularly in soft water, to many kinds of fish, crustaceans, mollusks, insects, phytoplankton, and zooplankton. Concentrations of copper, for example, are detrimental to some oysters above 0.1 ppm. Oysters cultured in seawater containing 0.13 to 0.5 ppm of copper deposited the metal in their bodies and became unfit as a food substance.

Tin (Sn)

Tin is not present in natural water, but it may occur in industrial wastes. Stannic and stannous chloride are used as mordants for reviving colors, dyeing fabrics, weighting silk, and tinning vessels. Stannic chromate is used in decorating porcelain, and stannic oxide is used in glass works, dye houses, and for fingernail polishes. Stannic sulfide is used in some lacquers and varnishes. Tin compounds are also used in fungicides, insecticides, and anti-helminthics.

No reports have been uncovered to indicate that tin is detrimental in domestic water supplies. Traces of tin occur in the human diet from canned foods, and it has been estimated that the average diet contains 17.14 mg of tin per day. Man can apparently tolerate 850 to 1000 mg per day of free tin in his diet.

On the basis of feeding experiments, it is unlikely that any concentration of tin that could occur in most natural waters would be detrimental to livestock. Most species of fish can withstand fairly

large concentrations of tin; however, tin is about ten times as toxic as copper to certain marine organisms such as barnacles and tubeworms.

While the inorganic compounds of tin are essentially non-toxic at the levels normally encountered, organotin compounds exhibit a high degree of toxicity to specific organisms. These are relatively recent innovations and little experience has been developed in their use.

Due to the potential hazards of organotins to marine environments and in light of the present lack of knowledge concerning the behavior of organotin waste in the environment, abrasive blasting waste containing organotin compounds should be considered pollutants of concern.

Lead (Pb)

Lead is used in various solid forms both as a pure metal and in several compounds. Lead appears in some natural waters, especially in those areas where mountain limestone and galena are found. Lead can also be introduced into water from lead pipes by the action of the water on the lead.

Lead is a toxic material that is foreign to humans and animals. The most common form of lead poisoning is called plumbism. Lead can be introduced into the body from the atmosphere containing lead or from food and water.

Lead cannot be easily excreted and is cumulative in the body over long periods of time, eventually causing lead poisoning with the ingestion of an excess of 0.6 mg per day over a period of years. It has been recommended that 0.05 mg/l lead not be exceeded in public water supply sources.

Chronic lead poisoning has occurred among animals at levels of 0.18 mg/l of lead in soft water and by concentrations under 2.4 mg/l in hard water. Farm animals are poisoned by lead more frequently than any other poison. Sources of this occurrence include paint and water with the lead in solution as well as in suspension. Each year thousands of wild waterfowl are poisoned from lead shot that is discharged over feeding areas and ingested by the waterfowl. The bacterial decomposition of organic matter is inhibited by lead at levels of 0.1 to 0.5 mg/l.

Fish and other marine life have had adverse effects from lead and salts in their environment. Experiments have shown that small concentrations of heavy metals, especially of lead, have caused a film of coagulated mucous to form first over the gills and then over the entire body probably causing suffocation of the fish due to this obstructive layer. Toxicity of lead is increased with a reduction of dissolved oxygen concentration in the water.

Chromium (Cr)

Chromium is an elemental metal usually found as a chromite (FeCr_2O_4). The metal is normally processed by reducing the oxide with aluminum.

Chromium and its compounds are used extensively throughout industry. It is used to harden steel and as an ingredient in other useful alloys. Chromium is also used in the electroplating industry as an ornamental and corrosion resistant plating on steel and can be used in pigments and as a pickling acid (chromic acid).

The two most prevalent chromium forms found in industry wastewaters are hexavalent and trivalent chromium. Chromic acid used in industry is a hexavalent chromium compound which is partially reduced to the trivalent form during use. Chromium can exist as either trivalent or hexavalent compounds in raw waste streams. Hexavalent chromium treatment involves reduction to the trivalent form prior to removal of chromium from the waste stream as a hydroxide precipitate.

Chromium, in its various valence states, is hazardous to man. It can produce lung tumors when inhaled and induces skin sensitizations. Large doses of chromates have corrosive effects on the intestinal tract and can cause inflammation of the kidneys. Levels of chromate ions that have no effect on man appear to be so low as to prohibit determination to date. The recommendation for public water supplies is that such supplies contain no more than 0.05 mg/l total chromium.

The toxicity of chromium salts to fish and other aquatic life varies widely with the species, temperature, pH, valence of the chromium and synergistic or antagonistic effects, especially that of hard water. Studies have shown that trivalent chromium is more toxic to fish of some types than hexavalent chromium. Other studies have shown opposite effects. Fish food organisms and other lower forms of aquatic life are extremely sensitive to chromium and it also inhibits the growth of algae. Therefore, both hexavalent and trivalent chromium must be considered harmful to particular fish or organisms.

Total Suspended Solids (TSS)

Suspended solids include both organic and inorganic materials. The inorganic compounds include sand, silt, and clay. The organic fraction includes such materials as grease, oil, tar, and animal and vegetable waste products. These solids may settle out rapidly and bottom deposits are often a mixture of both organic and inorganic solids. Solids may be suspended in water for a time, and then settle to the bed of the stream or lake. These solids discharged with man's wastes may be inert, slowly biodegradable materials, or rapidly decomposable substances. While in suspension, they increase the

turbidity of the water, reduce light penetration, and impair the photosynthetic activity of aquatic plants.

Suspended solids in water interfere with many industrial processes, cause foaming in boilers, and incrustations on equipment exposed to such water, especially as the temperature rises. They are undesirable in process water used in the manufacture of steel, in the textile industry, in laundries, in dyeing, and in cooling systems.

Solids in suspension are aesthetically displeasing. When they settle to form sludge deposits on the stream or lake bed, they are often damaging to the life in water. Solids, when transformed to sludge deposits, may do a variety of damaging things, including blanketing the stream or lake bed and thereby destroying the living spaces for those benthic organisms that would otherwise occupy the habitat. When of an organic nature, solids use a portion of all of the dissolved oxygen available in the area. Organic materials also serve as a food source for sludgeworms and associated undesirable organisms.

Disregarding any toxic effect attributable to substances leached out by water, suspended solids may kill fish and shellfish by causing abrasive injuries and by clogging gills and respiratory passages of various aquatic fauna. Indirectly, suspended solids are inimical to aquatic life because they screen out light, and they promote and maintain the development of noxious conditions through oxygen depletion. This results in the killing of fish and fish food organisms. Suspended solids also reduce the recreational value of the water.

Oil and Grease

Because of widespread use, oil and grease occur often in wastewater streams. These oily wastes may be classified as follows:

- o Light Hydrocarbons - These include light fuels such as gasoline, kerosene, jet fuel, and miscellaneous solvents used for industrial processing, degreasing, or cleaning purposes. The presence of these light hydrocarbons may make the removal of other heavier oily wastes more difficult.
- o Heavy Hydrocarbons, Fuels, and Tars - These include the crude oils, diesel oils, #6 fuel oil, residual oils, slop oils, and in some cases, asphalt and road tar.
- o Lubricants and Cutting Fluids - These generally fall into two classes: non-emulsifiable oils such as lubricating oils and greases and emulsifiable oils such as water soluble oils, rolling oils, cutting oils, and drawing compounds.

Emulsifiable oils may contain fat soap or various other additives.

- o Vegetable and Animal Fats and Oils - These originate primarily from processing of foods and natural products.

These compounds can settle or float and may exist as solids or liquids depending upon factors such as method of use, production process, and temperature of wastewater.

Oils and grease even in small quantities cause troublesome taste and odor problems. Scum lines from these agents are produced on water treatment basin walls and other containers. Fish and waterfowl are adversely affected by oils in their habitat. Oil emulsions may adhere to the gills of fish causing suffocation, and the flesh of fish is tainted when microorganisms that were exposed to waste oil are eaten. Deposition of oil in the bottom sediments of water can serve to inhibit normal benthic growth. Oil and grease exhibit an oxygen demand.

Levels of oil and grease which are toxic to aquatic organisms vary greatly, depending on the type and the species susceptibility. However, it has been reported that crude oil in concentrations as low as 0.3 mg/l is extremely toxic to freshwater fish. It has been recommended that public water supply sources be essentially free from oil and grease.

Oil and grease in quantities of 100 l/sq km (10 gallons/sq mile) show up as a sheen on the surface of a body of water. The presence of oil slicks prevent the full aesthetic enjoyment of water. The presence of oil in water can also increase the toxicity of other substances being discharged into the receiving bodies of water. Municipalities frequently limit the quantity of oil and grease that can be discharged to their wastewater treatment systems by industry.

Acidity and Alkalinity (pH)

Although not a specific pollutant, pH is related to the acidity or alkalinity of a wastewater stream. It is not a linear or direct measure of either, however, it may be used properly as a surrogate to control both excess acidity and excess alkalinity in water. The term pH is used to describe the hydrogen ion - hydroxyl ion balance in water. pH measures the hydrogen ion concentration or activity present in a given solution. pH numbers are the negative common logarithm of the hydrogen ion concentration. A pH of 7 indicates neutrality or a balance between free hydrogen and free hydroxyl ions. A pH above 7 indicates that the solution is alkaline, while a pH below 7 indicates that the solution is acid.

Knowledge of the pH of water or wastewater is useful in determining necessary measures for corrosion control, pollution control, and disinfection. Waters with a pH below 6.0 are corrosive to water works structures, distribution lines, and household plumbing fixtures and such corrosion can add constituents to drinking water such as iron, copper, zinc, cadmium, and lead. Low pH waters not only tend to dissolve metals from structures and fixtures but also tend to redissolve or leach metals from sludges and bottom sediments. The hydrogen ion concentration can affect the "taste" of the water and at a low pH, water tastes "sour."

Extremes of pH or rapid pH changes can exert stress conditions or kill aquatic life outright. Even moderate changes from "acceptable" criteria limits of pH are deleterious to some species. The relative toxicity to aquatic life of many materials is increased by changes in the water pH. For example, metalocyanide complexes can increase a thousand-fold in toxicity with a drop of 1.5 pH units. Similarly, the toxicity of ammonia is a function of pH. The bactericidal effect of chlorine in most cases is less as the pH increases, and it is economically advantageous to keep the pH close to 7.

Acidity is defined as the quantitative ability of a water to neutralize hydroxyl ions. It is usually expressed as the calcium carbonate equivalent of the hydroxyl ions neutralized. Acidity should not be confused with pH value. Acidity is the quantity of hydrogen ions which may be released to react with or neutralize hydroxyl ions while pH is a measure of the free hydrogen ions in a solution at the instant the pH measurement is made. A property of many chemicals, called buffering, may hold hydrogen ions in a solution from being in the free state and being measured as pH. The bond of most buffers is rather weak and hydrogen ions tend to be released from the buffer as needed to maintain a fixed pH value.

Highly acid waters are corrosive to metals, concrete and living organisms, exhibiting the pollutional characteristics outlined above for low pH waters. Depending on buffering capacity, water may have a higher total acidity at pH values of 6.0 than other waters with a pH value of 4.0.

RATIONALE FOR REJECTION OF POLLUTION PARAMETERS

A number of parameters shown in Table VI-2 have been rejected as pollution parameters. This rejection was based on negative answers to one or both of the questions used to select pollution parameters. Rejected parameters are listed in Table VI-4. A brief discussion of the rejected parameters and the rationale follows.

Table VI-4. PARAMETERS REJECTED AS POLLUTION PARAMETERS

| <u>Specific Parameters</u> | | <u>Non-Specific</u> |
|----------------------------|-------------------|---------------------|
| <u>Metals</u> | <u>Non-Metals</u> | <u>Parameters</u> |
| As | Mn | PO ₄ |
| Hg | Al | NO ₂ |
| Fe | | Total Solids |
| Cd | | Dissolved Solids |
| Ni | | COD |
| | | BOD |

Arsenic has been rejected because its use in antifouling paints has been discontinued due to toxicity. Mercury also formerly was included as a constituent of antifouling paints. However, on March 29, 1972, the EPA suspended its use in marine paints, and since that use was not subject to appeal (although its use in other paint formulations was appealed), it no longer is found in shipbuilding and repair facilities. If further investigation reveals the presence of arsenic in foreign paints which are subsequently removed in U.S. facilities, then it shall become a selected pollutant.

Iron has been rejected because, except for trace quantities in spent paint both as a pigment component and as rust blasted from the hulls, its presence in shipbuilding and repair facilities is in the form of structural steel, or at levels below immediate concern.

Cd, Ni, and Mn are unlikely constituents to arise from shipyard operations. No uses of these materials in shipyards have been identified. Aluminum may be present but is not considered a significant pollutant. Aluminum in the form of alum is commonly used in water treatment plants.

Phosphates and nitrites have been eliminated. Both are potentially detrimental to natural water bodies, but the only source is from wet blasting to bare metal. In this operation they are added to the water in fractional percentages as rust inhibitors. Wet blasting to bare metal is rarely used in shipyard practice because of the formation of rust on the unpainted surface.

COD and BOD have also been rejected. COD occurs as a result of the presence of reducing chemical compounds in the wastewater. The only reducing chemical species identified are nitrites, and these have been rejected as a parameter. BOD results from biological (sanitary) wastes and is not within the scope of this study.

SECTION VII

TREATMENT AND CONTROL TECHNOLOGY

INTRODUCTION

Treatment and control of shipyard discharges is subject to problems not encountered in most industries. One example is the volume of water involved in graving dock dewatering or raising floating drydocks. Graving dock volumes shown in Table III-8 range from 3.8 million liters (1.0 million gallons) to 246 million liters (65 million gallons). Dewatering may be carried out in four hours or less and at the upper size extreme the flowrate during dewatering would be 60 million liters (16 million gallons) per hour or the equivalent of 476 million liters (390 million gallons) per day. Floating drydocks are open ended, and confinement of volumes of water equivalent to that found in graving docks would make it impossible to raise the dock. Thus, flooding and dewatering operations defy practical wastewater treatment.

There are, however, a number of practices which can potentially benefit the discharges of industrial and other waters from both graving docks and floating drydocks. In the course of this study, these practices, which constitute the treatment and control technology in use or under development, were observed or reported to the contractor by facilities visited or contacted.

Seven facilities were visited and thirty-eight were contacted by telephone. From the information obtained, the treatment and control technology in use basically consists of (1) clean-up procedures in the dock and (2) control of water flows within the dock. The degree to which the available control measures are implemented by any yard depends upon conditions prevailing at the facility, physical constraints within the facility, economic factors, and, to a large extent, management philosophy.

All facilities practice some degree of clean up at various times, although this may consist only of moving debris out of the work area when accumulations interfere with operations. During the docking period, some facilities use extensive clean-up procedures, not only to remove debris prior to flooding, but to eliminate possible contact with gate leakage, hydrostatic water, or rainwater. In general drydock clean up is directed toward improving productivity and safety and toward maintaining acceptable working conditions. Both mechanical and manual methods are in use.

Mechanical clean-up methods used or tried include mechanical sweepers, front loaders, vacuum equipment and closed cycle blasting. Manual methods include shovels, brooms, and hoses.

Control of water flows within the dock, like clean-up procedures, varies with facility. In some cases, no controls of wastewater from either the docked vessel, industrial activities, leakage, or other natural causes are practiced.

Other facilities use methods to control and segregate water flows or have plans to implement such control. Generally, control and segregation of water flows in the dock, when practiced, has been for the same purposes as clean up, i.e., productivity, safety, and improved working conditions. However, recently, particularly in naval facilities, this form of control has the added purpose of eliminating potential discharge of pollutants.

In summary the treatment and control technology being applied or planned for drydocks consists of clean-up procedures and control and segregation of water flows. The objectives of clean-up activities are:

- o To improve productivity by removing physical obstacles and impediments to men and machinery working in the dock.
- o To improve safety by eliminating hazardous materials and conditions from the work area.
- o To improve working conditions by eliminating health (and safety) hazards and factors detrimental to morale.
- o To prevent potential contaminants from being discharged to the atmosphere or waterways.

Where control and segregation of water flows within the docks are in use or planned the objectives are:

- o To segregate sanitary waste, cooling water, industrial wastewaters, and leakages in order to comply with existing regulations governing sanitary wastes.
- o To comply with existing regulations governing oil spills and discharges.
- o To prevent transport of solids to the waterway way and contact of wastewater with debris in the drydock.

Management practices consistent with attaining these objectives have been defined. These represent actions and philosophies which can be

adopted in the normal course of shipyard operations. As such they can be set forth in general terms, and the particular conditions prevailing at each facility will determine the details and methods of implementation. The best management practices are presented below.

The following specific requirements shall be incorporated in NPDES permits and are to be used as guidance in the development of a specific facility plan. Best Management Practices (BMP) numbered 2, 5, 7 and 10 should be considered on a case-by-case basis for yards in which wet blasting to remove paint or dry abrasive blasting do not occur, and BMP 10 does not apply to floating drydocks.

BEST MANAGEMENT PRACTICES (BMP)

BMP 1. Control of Large Solid Materials. Scrap metal, wood and plastic, miscellaneous trash such as paper and glass, industrial scrap and waste such as insulation, welding rods, packaging, etc., shall be removed from the drydock floor prior to flooding or sinking.

BMP 2. Control of Blasting Debris. Clean-up of spent paint and abrasive shall be undertaken as part of the repair or production activities to the degree technically feasible to prevent its entry into drainage systems. Mechanical clean-up may be accomplished by mechanical sweepers, front loaders, or innovative equipment. Manual methods include the use of shovels and brooms. Innovations and procedures which improve the effectiveness of clean-up operations shall be adapted, where they can be demonstrated as preventing the discharge of solids. Those portions of the drydock floor which are reasonably accessible shall be "scraped or broomed clean" of spent abrasive prior to flooding.

After a vessel has been removed from the drydock and the dock has been deflooded for repositioning of the keel and bilge blocks, the remaining areas of the floor which were previously inaccessible shall be cleaned by scraping or broom cleaning prior to the introduction of another vessel into the drydock. The requirement to clean the previously inaccessible area shall be waived either in an emergency situations or when another vessel is ready to be introduced into the drydock within fifteen (15) hours. Where tides are not a factor, this time shall be eight (8) hours.

BMP 3. Oil, Grease, and Fuel Spills. During the drydocked period oil, grease, or fuel spills shall be prevented from reaching drainage systems and from discharge with drainage water. Cleanup shall be carried out promptly after an oil or grease spill is detected.

- BMP 4. Paint and Solvent Spills. Paint and solvent spills shall be treated as oil spills and segregated from discharge water. Spills shall be contained until clean-up is complete. Mixing of paint shall be carried out in locations and under conditions such that spills shall be prevented from entering drainage systems and discharging with the drainage water.
- BMP 5. Abrasive Blasting Debris (Graving Docks). Abrasive blasting debris in graving docks shall be prevented from discharge with drainage water. Such blasting debris as deposits in drainage channels shall be removed promptly and as completely as is feasible. In some cases, covers can be placed over drainage channels, trenches, and other drains in graving docks to prevent entry of abrasive blasting debris.
- BMP 6. Segregation of Waste Water Flows in Drydocks. The various process wastewater streams shall be segregated from sanitary wastes. Gate and hydrostatic leakage may also require segregation.
- BMP 7. Contact Between Water and Debris. Shipboard cooling and process water shall be directed so as to minimize contact with spent abrasive and paint and other debris. Contact of spent abrasive and paint by water can be reduced by proper segregation and control of wastewater streams. When debris is present, hosing of the dock should be minimized. When hosing is used as a removal method, appropriate methods should be incorporated to prevent accumulation of debris in drainage systems and to promptly remove it from such systems to prevent its discharge with wastewater.
- BMP 8. Maintenance of Gate Seals and Closure. Leakage through the gate shall be minimized by repair and maintenance of the sealing surfaces and proper seating of the gate. Appropriate channelling of leakage water to the drainage system should be accomplished in a manner that reduces contact with debris.
- BMP 9. Maintenance of Hoses, Soil Chutes, and Piping. Leaking connections, valves, pipes, hoses, and soil chutes carrying either water or wastewater shall be replaced or repaired immediately. Soil chute and hose connections to the vessel and to receiving lines or containers shall be positive and as leak free as practicable.
- BMP 10. Water Blasting, Hydroblasting, and Water-Cone Abrasive Blasting (Graving Docks). When water blasting, hydroblasting, or water-cone blasting is used in graving docks to remove paint from surfaces, the resulting water and

debris shall be collected in a sump or other suitable device. This mixture then will be either delivered to appropriate containers for removal and disposal or subjected to treatment to concentrate the solids for disposal and prepare the water for reuse or discharge.

CURRENT TREATMENT AND CONTROL TECHNOLOGIES

Most of the current efforts toward water pollution control in both graving docks and floating drydocks are derived from the recommendations of the rationale for shipbuilding and ship repair facilities published by the Denver branch of EPA's National Field Investigations Center in 1974, (Reference 2), after observing the practices in effect in some shipyards. That document emphasized the segregation of wastewaters and general housekeeping practices. It was recommended that all water flows be intercepted or otherwise controlled in order to prevent contact with spent paint and abrasive and other solid materials on the drydock floor. Procedures for handling particular water flows, cooling water, hydrostatic relief water, gate leakage, and air scrubber water were specified. Miscellaneous trash was to be eliminated through "the diligent use of waste receptacles or a thorough clean up...prior to flooding." Clean up of the drydock floor to "broom clean conditions" prior to each undocking was recommended.

Many of the shipyards contacted or visited during the course of this study have made efforts to comply with these recommendations. Their efforts fall into two general areas (as set forth in Table VII-1):

- o Clean up of abrasive
- o Control of wastewater flows

The extent to which particular treatment and control technologies were found to exist during the contact and visit phase of this study are shown in Table VII-2.

The following paragraphs describe observed sequences of the drydock treatment and control technologies listed in Table VII-3. It should be noted that certain of these processes and technologies are designed to reduce or eliminate effluents in drainage pump discharges and overboard flows from floating drydocks. Others are effective on the much larger discharges which occur during deflooding and sinking. The next few pages document procedures for the clean-up of spent abrasive and other solid drydock debris at seven shipyards which were visited and observed (labeled shipyards A through G) as well as procedures for handling cooling water discharges.

Table VII-1. WATER QUALITY TREATMENT AND CONTROL TECHNOLOGIES CURRENTLY BEING USED IN DRYDOCKS

| <u>Purpose</u> | <u>Technology</u> | <u>Pollutants Possibly Affected</u> | <u>Applicability</u> |
|--|---|-------------------------------------|----------------------|
| Clean-up of Abrasive From Drydock Floor | Front Loader | FLO, SUS, SET, HM | GD, FD |
| | Hand Shovel and Broom | FLO, SUS, SET, HM | GD, FD |
| From Drainage Trenches | Backhoe | FLO, SUS, SET, HM | GD |
| | Hand Shovel | FLO, SUS, SET, HM | GD |
| Control of Wastewater Flows | Sill, Channeling, or Trench Drain for Control of Gate Leakage and Hydrostatic Relief | FLO, SUS, SET, HM, O | |

FLO = Floating Solids
 SUS = Suspended Solids
 SET = Settling Solids
 O = Oil and Grease
 HM = Heavy Metals and Other Chemical Constituents

pH = pH
 Air = Particulates
 SOLIDS = Solid Waste
 GD = Graving Dock
 FD = Floating Drydock

Table VII-2. WATER QUALITY TREATMENT AND CONTROL TECHNOLOGIES UNDER DEVELOPMENT OR NOT BEING USED IN DRYDOCKS

| <u>Purpose</u> | <u>Technology</u> | <u>Pollutants Intended To Be Affected</u> | <u>Applicability</u> |
|---|---|---|----------------------|
| Clean-up of Abrasive From Drydock Floor From Drydock Floor or Drainage Trenches | Mechanical Sweeper | FLOW, SET, SUS, HM | GD, FD |
| | Vacuum Recovery Equipment (Stationary or Mobile) | FLO, SET, SUS, HM | GD, FD |
| Alternative To Conventional Dry Abrasive Blasting | Water Cone Abrasive Blasting | AIR | GD, FD |
| Abrasive Blasting | Wet Abrasive Blasting | AIR | GD, FD |
| | Hydroblasting (Steady Stream or Cavitation) | AIR, SET, SUS, HM, SOLIDS | GD, FD |
| | Closed-Cycle Abrasive Blast and Recovery | AIR, SET, SUS, HM, SOLIDS | GD, FD |
| | Cyclone Separation and Chemical-Physical Pretreatment | AIR, SET, SUS, HM, SOLIDS pH | GD, FD |
| Control of Wastewater Flows | Channeling for Improved Floor Drainage | SET, SUS, HM, O | GD |
| | Curbing & Channeling on Floating Drydocks | SET, SUS, HM, O | FD |
| | Scrapper Boxes, Hose, Piping, and/or Pumps for Clean Water Discharges | SET, SUS, HM, O | GD, FD |
| | Cover Plates to Prevent Abrasive from Entering Drainage System | SET, SUS, HM | GD |
| | Containment of Flows from Wet Blasting | SET, SUS, HM, O | GD, FD |
| Treatment of Wastewater Flows | Baffle Arrangement for Settling in the Drainage System | SET, SUS | GD |
| | Contained Absorbent in Discharge Flow Path | O | GD |
| | Wire Mesh in Discharge Flow Path | FLO | GD |
| | Adaptation of Pontcons for Settling Solids | SET, SUS, O | FD |
| Access for Clean-up Operations | Flat Floor Overlay | FLOW, SET, SUS, HM | GD, FD |
| | Removal of Bilge Block Slides | FLO, SET, SUS, HM | GD, FD |
| | Increased Keel Block Clearance | FLO, SET, SUS, HM | GD, FD |
| | Hydraulic Bilge Blocks | FLO, SET, SUS, HM | GD, FD |
| | | | |

S = Sewage
 FLO = Floating Solids
 SUS = Suspended Solids
 SET = Settleable Solids

O = Oil and Grease
 HM = Heavy Metals and Other Constituents
 pH = pH

AIR = Particulates
 GD = Graving Docks
 FD = Floating Drydocks
 SOLIDS = Solid Waste

Table VII-3. REPORTED APPLICATION OF THE TREATMENT AND CONTROL TECHNOLOGIES

| Purpose | Technology | Shipyards Visited | | | | | | | Shipyards Contacted (H Through A) | | |
|---|--|-------------------|----|----|---|----|----|----|-----------------------------------|------------|--------------------------|
| | | A | B | C | D | E | F | G | Use | Do Not Use | Insufficient Information |
| Clean-Up of Abrasive From Drydock Floor | Front Loader | * | * | * | * | * | X | * | 21 | 7 | 2 |
| | Mechanical Sweeper | X | X | * | X | * | X | X | 1 | 27 | 2 |
| | Hand Shovel | * | * | * | * | * | X | * | 26 | 1 | 3 |
| | Broom | X | X | X | * | * | X | X | 5 | 20 | 5 |
| | Vacuum Recovery Equipment | X | X | X | Z | X | X | X | 2 | 26 | 2 |
| From Drainage Ditches | Backhoe | X | X | NA | X | X | * | NA | 0 | 0 | 30 |
| | Hand Shovel | * | * | NA | * | * | * | NA | 0 | 0 | 30 |
| | Vacuum Recovery Equipment | X | X | NA | X | X | X | NA | 0 | 0 | 30 |
| | Container Lifted by Crane | X | X | NA | X | X | * | NA | 0 | 0 | 30 |
| Alternative to Conventional Dry Abrasive Blasting | Water Cone Abrasive Blasting | X | X | X | * | X | X | X | 0 | 0 | 30 |
| | Wet Abrasive Blasting | X | X | X | * | * | X | X | 0 | 4 | 26 |
| | Hydroblasting | | | | | | | | | | |
| | Steady Stream | X | X | X | X | X | X | X | 3 | 4 | 23 |
| | Cavitation | X | X | X | X | X | X | X | 0 | 0 | 30 |
| | Closed Cycle Abrasive Blast and Recovery | X | X | X | Z | X | X | Z | 1 | 28 | 1 |
| | Cyclone Separation | X | X | X | X | Z | X | X | 0 | 0 | 30 |
| Chemical-Physical Pretreatment | | | | | | | | | | | |
| Control of Waste-water flows | Sill, Channeling, or Trench Drain for Control of Gate Leakage and Hydrostatic Relief | * | * | NA | * | * | * | NA | 0 | 0 | 30 |
| | Channeling for Improved Floor Drainage | X | X | X | * | X | X | X | 0 | 0 | 30 |
| | Curbing and Channeling of Floating Drydocks | X | NA | X | X | NA | NA | X | 0 | 0 | 30 |
| | Scupper Boxes, Hose, Piping, and Pumps for Clean Water Discharges | * | * | * | * | * | X | X | 4 | 5 | 21 |
| | Cover Plates to Prevent Abrasive from Entering Drainage System | X | X | NA | X | * | X | NA | 0 | 0 | 30 |
| | Containment of Floor from Wet Blasting | X | NA | NA | X | * | NA | NA | 0 | 0 | 30 |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| Treatment of Wastewater Flows | Baffle Arrangement for Settling in the Drainage System | X | Z | NA | X | X | X | NA | 0 | 0 | 30 |
| | Contained Absorbent in Drainage Discharge Flow Path | X | X | NA | X | X | | NA | 0 | 0 | 30 |
| | Wire Mesh in Drainage Discharge Flow Path | X | X | NA | X | NA | NA | NA | 0 | 0 | 30 |
| | Adaptation of pontoons for Settling Solids | X | NA | X | X | NA | NA | X | 0 | 0 | 30 |

NOTE: * = Use
X = Do Not Use
Z = Planned, Infrequent Use, or Under Development
NA = Not Applicable

Most of the facilities visited perform a manual pick up of large debris prior to each undocking. Such debris includes scrap metal, large wood chips or blocks, metal cans, scrap paper, paint cans, and the like. After this manual pick up, with the aid of shovels, the debris is deposited into receptacles on the drydock floor for removal and disposal. Some shipyards require this procedure at the end of each shift. Upon completion of this phase, only spent abrasive and other small sized debris remain on the drydock floor. A variety of procedures and technologies to remove the remaining substances were observed.

At many shipyards, no efforts are made to remove spent abrasive from the drydock floor prior to flooding. Docks servicing fresh water vessels rarely do any extensive blasting and consequently do not have spent abrasive to collect. In some cases contractual requirements do not allow time for clean up. Some companies regard the clean up process as difficult, time-consuming, labor-intensive, and hence expensive. The practice of no clean up was observed in smaller or older drydocks, particularly those with raised bilge block slides and those not requiring keel or bilge block movement prior to the next docking. The necessity for clean up is perceived at these docks only when accumulations of spent abrasive reach such levels that it interferes with keel or bilge block placement or movement, creates hazardous working conditions, or reduces productivity. Those conditions may be reached after only a few ships have been serviced or after many. Clean up may be as frequent as weekly or as infrequent as semiannually.

When clean up is necessary, front loaders are usually placed on the drydock floor. With graving docks, cranes are required to lower the machinery into the dock basin. The front loader is often modified to permit access to the floor beneath the ships hull and consequently to operate while the ship is still in dock. The loaders scrape and push the spent abrasive into piles. Men with shovels and the front loaders then place the accumulated waste in containers or hoppers.

When bilge block slides are present or low keel blocks are employed, the efficiency of operation of the front loaders is greatly reduced. The equipment has difficulty in passing over bilge block slides. Frequent stopping and starting, climbing and falling wears down the equipment and is time consuming. Laborers with shovels must manually clean areas inaccessible to the front loader, such as beneath the hull and around the blocks and slides.

To remove the remaining grit some shipyards use manual sweepers. Workers with push brooms sweep the abrasive into piles which are transferred to the hoppers.

In a few instances mechanical sweepers are also used. One sweeper, a modified 1-3/4 ton truck, employs horizontal and vertical rotary brushes to loosen and pick up spent abrasive and other debris from the floor. These wastes are collected inside the sweeper. The sweeper can make two passes along the length of the dock before becoming full; then it must be emptied before continuing. The sweeper dumps its contents in a pile on the floor of the drydock. The pile is then loaded into containers by front loaders and laborers with shovels.

The mechanical sweeper has no arrangements for reaching around or under obstructions. It is also too high to clean under ships and can only clean those areas over which it passes. The sweeper cannot operate effectively unless the floor is clear of removable obstructions such as scupper hoses, hoppers of abrasive, scaffolding, and materials being used in the drydock (paint cans, metal plates, etc.). Thus, the sweeper does not begin clean up until after exterior work on the hull has been completed. When a large ship has been docked, there is little clearance along the sides or at the end of the dock. In such cases, space does not allow for the sweeper to be used prior to undocking.

Shipyard A has two graving docks and three floating drydocks. It utilizes scupper boxes and hoses to direct cooling water discharges from the vessel to the drydock drains and ultimately to the harbor. Graving dock caisson leaks are intercepted at the outboard end of the dock and pumped back to the harbor without coming into contact with solid wastes on the floor of the graving dock. Hydrostatic leakage flows to drainage trenches along the periphery of the floor and is pumped to the harbor. The wastes are invariably wet and packed from flooding or sinking of the dock, from rain, and from the movement and placement of equipment, men and materials. This makes the drydock floor at Shipyard A difficult to clean thoroughly. Also, Shipyard A drydocks have bilge block slides that are raised above the dock surface and interfere with cleaning operations.

Clean up occurs whenever abrasive buildup has reached a depth such that the bilge blocks can no longer be repositioned on the bilge slides. This is necessary following approximately five dockings. When clean up is necessary, front loaders are brought in to scoop and scrape the drydock floor. Wastes are accumulated in piles, then collected in containers using front loaders and shovels. The containers are lifted out of the drydock by cranes and placed onto or emptied into trucks. Laborers with hand shovels accompany the front loaders, primarily under the hull and at the bilge blocks and their slides.

Shipyard B has five graving docks and cleans up spent abrasive and related debris prior to each undocking. The clean up procedure of Shipyard B is identical to that of Shipyard A except that it is

performed more frequently. As the time for undocking approaches, front loaders and laborers with shovels clean the floor. In Shipyard B, the wastes are frequently dry. Shipyard B has no raised bilge block slides. Thus, the clean up at Shipyard B is ordinarily less time consuming per occurrence than the clean up at Shipyard A. Shipyard B uses scupper boxes and hoses to direct cooling water discharges to the drydock drains. The hoses observed, however, were in poor shape and considerable leakage flowed across the drydock floor. The discharges are pumped from the drains to the harbor. Caisson leakage is intercepted at the outboard end of the docks and pumped to the harbor. Hydrostatic relief and leakage waters flow to trenches along the periphery of the dock and are pumped to the harbor.

Shipyard C has two flush decked floating drydocks and also cleans prior to and after each undocking. The cleaning is performed using a mechanical sweeper and a front loader. The sweeper and front loader are utilized to clean as best as practicable before flooding. Following flooding and undocking of the vessel, the sweeper and front loader are returned to the dock and work unimpeded (except for the keel blocks and bilge blocks) and effect a complete cleaning operation. In every case, the sweeper completes its clean up including areas previously inaccessible subsequent to flooding, undocking, and deflooding but before the docking of the next vessel.

Shipyard D has three graving docks and two floating drydocks. Clean up of spent abrasive and associated debris is performed on a continuing basis. Upon completion of a blasting operation, front loaders and shovels are brought in to collect the wastes into piles and then load them into containers. This operation may occur several times during a single docking depending on the scheduling of abrasive blasting. Following the use of front loaders and shovels, laborers use push brooms to sweep the docks. Just before undocking, the front loaders, shovels, and brooms are returned to the drydock floor for a final comprehensive clean up. On occasion, remaining wastes are hosed to the drainage system. The drainage system and the flooding tunnel are shovelled out on an as-required basis, but not necessarily prior to each undocking. Scupper boxes and hoses are attached to the vessel in drydock to direct cooling waters to drains discharging to the harbor. Hydrostatic leakage water and water from internal tank blasting units flow across the drydock floor to overboard drains where they are pumped to the harbor.

Shipyard E has one graving dock. The clean up at Shipyard E begins with front loaders and shovels. The shovellers accompany the front loaders in addition to cleaning those areas the front loaders cannot reach or cannot clean effectively, such as at corners and surfaces or between bilge blocks. Wastes are consolidated into piles before being loaded into containers. A mechanical sweeper follows the front loaders and shovels. The sweeper works like the sweeper at Shipyard

C. If these procedures do not result in a satisfactory floor condition, shovels and push brooms are used to complete the job. Flooding ports in the dock floor are shovelled out prior to each undocking. The flooding tunnel is inspected and shovelled out if necessary. Stairways are swept manually, as are the utility dugouts and the altar. Areas adjacent to the dock are cleaned by a small, mobile, mechanical sweeper the size of a small front loader. No hosing of abrasive is performed at Shipyard E during the clean up prior to undocking. Clean up of abrasive and debris occurs for each ship at the end of its stay in the drydock, not on an ongoing basis as is the practice at Shipyard D. Scupper boxes and hoses are attached to the vessel after drydocking to direct cooling water discharges to drains to the harbor. The graving dock was dry with no evidence of hydrostatic relief or leakage water in the dock during the visit to this shipyard.

All of the shipyards described up to this point service primarily saltwater ships which require high levels of abrasive blasting. Some shipyards service only freshwater ships. Clean-up procedures and technologies at these yards are correspondingly different.

Shipyard F has two graving docks and services vessels that sail in fresh (inland) waters. This facility does very little abrasive blasting. Ships at this yard receive no abrasive blast treatment at all to remove paints. Shipyard F has no mechanized equipment for the removal of spent abrasive and other granular debris. It performs no clean up of such materials prior to undocking. Large debris is picked up manually. After flooding, undocking, and the subsequent deflooding, material accumulated on the drydock floor (which at this point includes silt and other debris which entered during flooding) is hosed to the drainage trenches. Hosing of the dock floor is carried out in order to maintain clean working conditions and to improve productivity. Therefore, the clean up is not always complete, especially at the ends of the dock, near the drainage trenches and away from working or dock entry areas. Little hosing is done on minor accumulations around the keel blocks or bilge blocks if no block movement is necessary. Periodically (every few months), the trenches fill and require cleaning. All drainage water from the graving docks is pumped into a sluice. A floating box containing an absorbent for oil and grease completely blocks the discharge end of the sluice. Water can flow under (the box extends only a short distance below the surface) and through the box, but floating oil and grease are removed by the absorbent.

All vessels are evacuated and shut down during drydocking; consequently, little or no water of any type is discharged to the graving docks during the servicing period. Caisson leaks and hydrostatic relief or leakage waters are collected in trenches and pumped through the sluice to the harbor.

Shipyard G has two floating drydocks. During ship repair on one of the floating drydocks (a flush deck dock), spent abrasive is consolidated into piles using front loaders and shovels. The piles are loaded into containers for disposal. This activity begins soon after abrasive blast operations have ended regardless of the remaining period for the ship to be in dock. Shipyard G does more abrasive blasting than Shipyard F, but rarely at levels comparable to the saltwater shipyards A, B, C, D, and E. Normally, the crew does not remain on board during drydocking at Shipyard G. Since shipboard services are shut down there are no cooling water discharges. On the second floating drydock (having bilge block slides on deck), spent paint and abrasive is cleaned up only when accumulations interfere with vessel repair operations or cause safety hazards. This occurs about twice a year. The vessel is evacuated during drydocking; consequently, there are no discharges from the ship.

CONTROL AND TREATMENT OF WASTEWATER FLOWS

In addition to clean up of solid wastes from the drydock floor, efforts to control and treat wastewater flows are being undertaken at many facilities. In the dewatered graving dock there are two streams of wastewater during ship repair operations: (1) cooling and process wastewater discharges, and (2) flows from various sources such as caisson leaks, hydrostatic relief or leakage, and industrial or process wastewater. Floating drydocks also have these wastewaters, with the exception of caisson and hydrostatic leaks. Process wastewaters include discharges from air scrubbers, wet grit blasting, and tank and bilge cleaning. Tank and bilge cleaning wastes are oil and water mixtures. A collection and holding tank system, usually the Wheeler (TM) type, is used to remove and separate this waste. Other wastewaters may be directed by hoses or allowed to flow across the floor into the graving dock drainage system, or directly to ambient waters from floating drydock pontoon decks. Miscellaneous water flows come from such sources as hydrostatic relief, non-contact cooling discharges, gate leakage, and pipe and fitting leakage. Existing dock drainage system designs allow process wastewaters to mix with other wastewater. They may contact solid wastes on the deck or in the trench before being discharged into ambient waters.

The volume of wastewater discharged from a ship in drydock may depend upon the point in the docking cycle. As shipboard equipment which uses water is being shut down following docking, the volume of discharge decreases. The continuing volume of discharge from the ship will depend upon the size of the crew remaining on board while in drydock. Some ship operators, such as the U.S. Navy, keep most of the operating crew on board even when the ship is drydocked for an extended period. This practice generates considerable volumes of wastewater. Other operators may shut down all equipment and remove the entire crew even for short drydocking periods.

Another factor bearing on the volume of water passing through a drydock is the effectiveness and level of maintenance effort applied by shipyard facility personnel to the many fittings and valves in the drydock potable and nonpotable water systems. Industrial water usage is minimal and higher flows occur only if wet abrasive blasting, water cone blasting, or hydroblasting is used. The use of hoses for clean up also contributes to wastewater volume. Drydock industrial waters are sometimes controlled by channels, sills, and drainage trenches. Some graving docks have arrangements for intercepting flows and conducting the water to drainage systems. This reduces contact of gate leakage and hydrostatic relief water solids on the drydock floor. Floating drydocks, on the other hand, generally lack arrangements for the containment of flows, and have no hydrostatic or gate leakage.

Graving dock drainage system designs vary widely but all involve networks of gutters, trenches, and/or culverts which serve to collect the heavier settleable solids transported in industrial wastewater flows. Unless promptly removed this debris may come in contact with water flows. To protect drainage pumps from excessive wear or damage, some drainage systems are designed with settling basins or sand traps to intercept and settle even the lighter particles. This removes transported particles from the discharge flow but may increase contact of water with solid wastes. Some of these settling locations, such as shallow transverse and longitudinal gutters in the drydock floor are relatively easy to clean out. Large longitudinal drainage culverts under the walls of graving docks can be extremely difficult to clean.

TREATMENT AND CONTROL TECHNOLOGIES UNDER DEVELOPMENT OR NOT IN COMMON USE

Many technologies are being developed that potentially can reduce solid waste, expedite clean up and control wastewater flows. In the section on "Control or Clean Up of Abrasive Through Access In Clean Up Operations" these technologies are discussed. The second half of Table VII-1 has summarized these developmental projects.

Control or Clean Up of Abrasive

High-suction vacuum grit removal equipment, such as the Vacu-Veyor (TM) unit, is used extensively to collect and remove debris from blasting operations in the ship's interior. Occasionally, however, the situation accommodates placing a container directly beneath an access hole cut through the ship's side, to collect the debris directly. Several existing kinds of equipment, not originally designed for drydock use, are being evaluated and modified to facilitate the removal of spent abrasive and debris. Vacu-Veyor (TM) units are relatively simple devices which are used in removing dry abrasive and debris from internal tank blasting operations and occasionally from drydock floors. They suffer, however, from a lack

of mobility and the airborne particulate material cannot be effectively contained when blown into open skip boxes (Reference 9). At least one shipyard is attempting to develop this equipment by enclosing the container and making the unit more easily moveable. Two other complex, high-suction vacuum machines are being evaluated and developed by shipyard facilities. They are the VAC-ALL (TM) (References 8, 9, & 12) and the VACTOR 700 (TM) (References 6 & 8) units. Both of these units have demonstrated tremendous capability to move large amounts of grit in a relatively short time but both, in their present configuration, have many limitations for drydock application. A third type of vacuum equipment being evaluated for use in removing grit and debris from drydock floors is a low profile self-propelled device called the ULTRA-VAC (TM) Grit Vacuum. It shows the most promise for application in flush floored drydocks and can best be described as a powerful vacuum cleaner on wheels (References 8, 9, & 12). Until a design evolves from the development of these three types of vacuum equipment that will meet the needs of the varying drydock characteristics, most facilities will be forced to resort to labor intensive, time consuming techniques to remove debris.

Alternatives to conventional dry abrasive blasting include water cone abrasive blasting, wet abrasive blasting, hydroblasting (steady stream or cavitation), and closed cycle abrasive blast and recovery. Some of these techniques have potential for reducing or eliminating the quantity of solids required in blasting but some substitute a water pollution problem for an air pollution problem. None of these technologies can completely replace conventional dry abrasive blasting and all are in various stages of development. Table VII-2 indicates which shipyards contacted are currently practicing these alternatives.

A variation of the wet grit method of abrasive blasting, called water cone, water envelopment, or water ring, is fairly new but rapidly gaining popularity particularly with increasing use of organotin antifouling paints on some Navy ships. This process projects a cone of water around the stream of air and abrasive as it leaves the hose nozzle. This is accomplished by a simple water ring accessory which fits around any standard blasting hose nozzle. This method has the advantages of dry grit blasting with less dust production. It does, however, add to the volume of industrial wastewater and rust inhibitors, when added, are present in the wastewaters (References 7 and 9).

Hydroblasting is a surface preparation method used when extensive, heavy abrading is not a requirement. In one technique a cavitating water jet is used as the abrading material. As explained in Reference 13:

"The basic concept simply consists of inducing the growth of vapor-filled cavities within a relatively low velocity liquid

jet. By proper adjustment of the distance between the nozzle and the surface to be fragmented, these cavities are permitted to grow from the point of formation, and then to collapse on that surface in the high pressure stagnation region where the jet impacts the solid material. Because the collapse energy is concentrated over many, very small areas at collapse, extremely high, very localized stresses are produced. This local amplification of pressure provides the cavitating water jet with a great advantage over a steady non-cavitating jet operating at the same pump pressure and flow rate."

Considerable success in laboratory experiments is claimed for the CAVIJET (TM) method but results of field evaluation are not available.

Several versions of closed-cycle vacuum abrasive blasting equipment are undergoing engineering development and operational evaluation at various shipyard facilities. They all operate on the principle of automatically recovering and reusing abrasives. Abraded coatings and fouling are sometimes separated and contained for land disposal. The machines, when operating as designed, are expected to eliminate both air and water pollution problems resulting from dust emissions and from solid wastes entering the drydock drainage system. If steel shot is used as the abrasive and is recovered, the solid waste load is reduced many times. Steel shot retains its cutting power even after repeated reuse. The closed-cycle blaster has limits however. These machines will not completely supplant other surface preparation techniques since they are large, heavy, and require considerable space for maneuvering. In addition, they are not designed to function on other than nearly flat or gently curving surfaces. More detailed information regarding some of these machines is provided in technical references to this document, particularly those prepared by or for the U.S. Navy.

Control of Wastewater Flow

The control and treatment of wastewater flows is critically tied to the segregation of wastewater streams. This philosophy is best expressed in a quote from Reference 6:

"The key to cessation of unnecessary liquid waste generation...is seen as segregation of wastes as completely as possible and reasonable. Unpolluted waters should be segregated from contaminated solid wastes and vice versa.

An appropriate system to collect and convey liquid waste must be capable of maintaining segregation until contaminated wastes are removed from the drydock and unpolluted wastes are properly discharged to harbor receiving waters."

This report proceeds with definitions of systems and techniques to segregate, collect, and transfer contaminated and uncontaminated wastewater streams (and materials causing contamination) to environmentally acceptable treatment systems.

A similar philosophy of approach was reported in Reference 11:

"A practical solution to eliminate the large volume of polluted wastewater discharge into the harbor would be segregation of clean water flows from both spent abrasive and any already polluted wastewaters. This is the basis for the following recommendations. Wastewaters can be divided into three streams. The first stream, comprised of hydrostatic water, ships' cooling water, and miscellaneous other equipment cooling water discharges, could be collected in what will be henceforth called the clean water conduit. These unpolluted waters could be discharged directly into the harbor without treatment. The second stream, comprised of drydock sanitary wastewater and ships' non-oily wastewater, could be collected in a sanitary sewer and pumped to a municipal sewage treatment plant. The third stream, comprising all other wastewater discharges including ships' oily wastewater, dock floor wash water, miscellaneous equipment washings, spills, sewer leaks, rain, and clean water which accidentally contacts the dock floor, could be collected in an industrial wastewater sewer and pumped to an industrial wastewater treatment facility."

The facility that served as a model for these two studies is planning the implementation of the recommended improvements.

Segregation of water flows is accomplished by physical isolation. Collection can be through either or both in-floor and above-floor plumbing systems. For example, above-floor systems can be fabricated from PVC piping and attached adjacent to keel blocks.

Treatment of Wastewater Flows

Innovative controls will be installed at one shipyard in its graving docks having large transverse trenches or cross drains near the outboard or drain end. Involved is an arrangement of baffles in the cross drain as a means of minimizing the discharge of settleable solids and floating material. The baffles will be installed so as to use the cross drain as a settling pond. A baffle acts as a dam to establish a water level and hence a retention time for settleable solids to separate. Water flowing over the top of this baffle will go directly to the drainage pump. Upstream of this overflow dam, a second baffle will be installed to form an underflow dam for holding floating debris, oil, or other substances for collection and removal prior to flooding the drydock. Both baffles will be removable, and

provisions will be made to drain off the water held behind them. Settleable solids contained within the cross trench will be removed for land disposal. The baffles will be installed after the ship is secure in the dock and the initial dewatering has been completed. The installation will not minimize the contact of solids with water streams, but is expected to reduce the potential of solids transport.

At one facility (Shipyard F), graving dock discharges, other than dewatering, are directed through a flume prior to emission to the adjacent river. Across this flume, near the discharge end, a floating box-like structure is placed in the flume after dewatering. The box-like structure holds a screen across the surface of the flow to prevent floating trash and debris from entering ambient waters. It is filled with absorbent material which removes oil and grease from the discharge flow. The absorbent material is replaced as needed.

Access In Clean-Up Operations

Two items of drydock design make efforts to clean up industrial wastes, such as abrasive blasting debris, more difficult and costly. They are the height of keel blocks and the existence of raised slides across the floor (or pontoon deck) for movement of bilge blocks.

Almost all existing drydocks have keel block heights of 3-1/2 to 6 feet. Older docks tend to have smaller keel blocks. With short keel blocks the working space between the drydock deck and ship bottom is too restricted for men using shovels and brooms to effectively clean up blasting debris and for using mechanized techniques currently available. This situation is most severe when the ship has a wide beam and a flat bottom. At least one new graving dock, currently under construction, will have 10-foot high keel blocks.

Graving docks and floating drydocks which have bilge block slides present a particularly severe problem to clean-up activities.

These solids establish corners and crevices from which fine debris is difficult to remove. They interfere with the movement of wheeled equipment and increase maintenance costs of the equipment used to clean up blasting debris (such as small front loaders). The positioning of these tracks across the flow direction of launch water may be beneficial, however, in acting as a submerged weir or dam, trapping sediment that would otherwise wash away.

NON-WATER QUALITY ENVIRONMENTAL ASPECTS

The control and treatment technologies described in this section are designed to improve the water quality of drydock discharges. However, some of these technologies also impact, either favorably or

unfavorably, on other environmental concerns, particularly air pollution and solid waste. This subsection addresses those impacts.

Air Pollution Several control technologies provide alternatives to conventional dry abrasive blasting. These alternatives include wet abrasive blasting, hydroblasting using either steady stream or cavitation, water cone abrasive blasting, closed cycle abrasive blast and recovery equipment, and chemical stripping. Comparison of these alternatives must include many considerations among which are the desirability and thoroughness of surface preparation, speed of application, labor costs, equipment modifications, capital required, occupational health and safety, and effects of possible contamination of water flows. However, all of the alternatives are extremely effective in the reduction or elimination of one of the most detrimental aspects associated with dry abrasive blasting, namely the production of airborne particulates.

Upon impact, abrasive particles fracture. The larger fragments fall to the drydock floor or occasionally to adjacent land or water areas. Smaller fragments, however, become airborne or suspended, along with some particles released from the blasted surface. Depending on the wind, they may travel appreciable distances. Shifting to harder blast media reduces these effects only slightly.

Most of the technologies listed above have been developed more as air pollution control measures than water pollution control measures. Closed-cycle abrasive blast and recovery equipment uses a vacuum to pull blast particles from the air as they are released. This equipment (of which there are several types in various stages of development) is not totally successful in the recovery of blast particles; however, the characteristic plume of dust emanating from dry abrasive blasting is eliminated and the level of airborne particulates and suspended solids is drastically reduced. Wet abrasive blasting and water cone abrasive blasting prevent the production of airborne particles by wetting blast fragments. The moisture-laden fragments then fall to the drydock floor or drip down the structure being blasted. Wet abrasive blasting is a particularly effective means of improving air quality in blasting. Water cone abrasive blasting, though not as effective, still reduces the air pollution problem to a local one involving only the blast nozzle operator and those in the immediate vicinity. Hydroblasting preempts the problem of abrasive fragmentation by eliminating the source, i.e., the abrasive. Only particles from the surface being blasted must be contended with and in hydroblasting, these particles are wet, causing virtually all to drop. Chemical stripping completely eliminates airborne particulates since it involves no blasting. Chemicals are brushed on, allowed to work, then scraped off manually. Because slow, labor-intensive methods are required, chemical stripping is used very little. This technology trades off particulate emission for

hydrocarbons and other chemical vapors caused by its high volatility. Closed-cycle blasters under development which use steel shot show promise of eliminating essentially all air and water pollution from blasting operations.

Vacuum material handling equipment can be a source of particulate emission where open collection containers are used. The magnitude of this emission depends on the geometry of the collection system, the volume and rate of material being moved, and the material composition, particularly its moisture content and particle weight. Vacuum equipment is ordinarily diesel powered and thereby contributes hydrocarbons, nitrogen oxides, carbon monoxide, and other emissions associated with diesel engine combustion. Mobile units have greater fossil fuel energy requirements than stationary units and thus produce higher levels of air pollution.

A number of the control technologies similarly affect air quality through requirements for power from local combustion equipment. Mobile sweepers and front loaders are examples. Pumping equipment on mobile floating drydocks are usually diesel powered, so that drydock design changes which result in the installation of pumping equipment may add to air emissions. Such design changes include modifying floating drydock pontoons for use as settling tanks, adding filtration equipment or extensive new piping, and other efforts to segregate wastewater flows which require additional pumping. Air emissions may not increase if the pumping requirements are split without increasing input energy requirements. Hydroblasting, by avoiding air as a propellant, reduces air emissions from local air compressor stations. This reduction occurs at the expense of emissions from the alternate compression source. The practice of shutting down shipboard equipment while in drydock also reduces air emissions, in this case, from fossil fueled equipment on board.

Solid Waste

Conventional dry abrasive blasting creates appreciable accumulations of solid waste. Where it is applicable, closed-cycle blast and recovery equipment can greatly reduce the quantity of abrasive required and alleviate the clean up of spent paint and abrasive. Disposal of the material, whether from open or closed-cycle blasting is required. Generally, solid wastes will be transported by a contractor to landfill disposal sites. Though the degree to which the wastes are potentially harmful has not been assessed, several considerations appear warranted. In order to ensure long-term protection of the environment from potentially harmful constituents, special considerations of disposal sites should be made. Landfill sites should be selected which prevent horizontal and vertical migration of constituents to ground or surface waters. In cases where geologic conditions are not suitable adequate mechanical precautions

(e.g., impervious liners) may be required to ensure long-term protection of the environment. A program of routine periodic sampling and analysis of leachates may be advisable. Where appropriate, the location of solid hazardous materials disposal sites, if any, should be permanently recorded in the appropriate office of legal jurisdiction.

Of particular concern is the disposal of the new organotin wastes. These toxic compounds which are sometimes used in antifouling paints may be present in the spent paint, as well as originating from paint spills and overspray. Currently the Navy, for example, requires that these wastes be sealed in drums and shipped to a properly managed landfill. These precautions are taken to prevent runoff, seepage, and possibly leaching of organotin compounds.

Other Environmental Aspects

In addition to air pollution and solid waste, some of the water control and treatment technologies exhibit minor effects in other environmental areas. The shut down of shipboard services reduces cooling water discharges and consequent thermal pollution. Noise is also reduced. Alternative technologies to dry abrasive blasting which do not employ air as a propellant (hydroblasting and wet abrasive blasting) reduce the load on shore-based air compressors and less heat is added to the water. Thermal discharges from this source are thus reduced. Vacuum material handling equipment and other engine-driven equipment (closed cycle abrasive blast and recovery equipment, mobile sweepers, front loaders, etc.) add to the general noise level in the drydocks.

SECTION VIII

COST OF TREATMENT AND CONTROL TECHNOLOGY

INTRODUCTION

The economics of currently applied treatment and control technology were obtained during shipyard visits. The technologies, as listed in Section VII, include:

- o Technologies for the clean up of abrasive
- o Alternatives to conventional dry abrasive blasting
- o Control technologies for wastewater flows excluding sewage
- o Treatment technologies for wastewater flows excluding sewage

The costs of clean-up and best management practices were developed from information obtained during visits to shipyards A through G. These represent a composite of costs for these seven facilities, and are not specific to any one of them. This information was obtained during the period March through May of 1976 and has not been adjusted for inflation occurring since that period.

The reported and observed application of these technologies appears in Table VII-2. Clean up of abrasive is practiced at each of the shipyards visited and has been for many years. Much cost information is available concerning technology for the clean up of abrasive. With the exception of scupper boxes and piping, and design features for the control of gate leakage and hydrostatic relief water, the other treatment and control technologies have found little application among the shipyards visited. Many of these technologies are in the planning, research, or experimental stages of development and could not be evaluated with respect to economics since actual cost data (particularly operation and maintenance costs) are unavailable. The cost data applies to current technologies for the clean up of abrasive as reported and observed during the shipyard visit program. Developmental methods are not considered.

Throughout the history of conventional dry abrasive blasting, it has been necessary for shipyards which use appreciable amounts of abrasive in their docks to clean it up periodically solely to continue in business. Abrasive on the drydock floor can adversely affect working conditions and productivity. It can hamper the placement and movement of bilge blocks. It hampers the movement of mechanized equipment. Consequently, shipyards have performed periodic clean up of abrasive from the drydock floor. However, in 1974, the EPA, through its

National Field Investigations Center in Denver, Colorado, recommended that shipyards increase their efforts to prevent wastewaters from contacting abrasive on the drydock floor and to clean up to "broom clean" conditions prior to flooding or sinking.

Response to EPA's recommendations has been mixed. It is very difficult to segregate clean-up costs for environmental purposes at these shipyards and those costs which would have been incurred during the normal course of business. The estimated costs developed here reflect stepped up efforts to reduce effluent discharges to nearby water bodies. But no effort is made to isolate the cost of these stepped up efforts. Costs presented later in this section are total costs of clean-up operations as currently performed.

The cost data include capital, labor, operating, and maintenance costs incurred directly during clean-up operations. Certain indirect costs could not be estimated accurately and are not included. A thorough clean up of drydock floor space, trenches, tunnels, and altars can lead to increased drydock time per ship. If such time is allowed for in contract arrangements with shipowners, busy shipyard operators may find that they cannot service as many ships per year and must correspondingly suffer a drop in revenue. If increased time for clean-up activities is not allowed for, the shipyard is faced with the loss in revenue or additional charges to the ship owner. Frequently at shipyards in this position, complete clean up prior to flooding is not performed. Either way, time delays create dissatisfied customers, and can harm shipyard reputations and good will as well as current and future business prospects. These are important considerations which can produce hidden costs not recognized as clean-up related.

On the other hand, the clean up of abrasive prior to flooding may provide some economic benefits. When abrasive blasting has been particularly heavy, collection of the abrasive may be required to profitably carry out repair operations on a vessel. Thus, increased clean-up efforts may provide benefits as well as increase costs. However, this section does not present a cost/benefit analysis of the operation. Only those costs are included that directly result from the clean-up methods discussed.

IDENTIFICATION OF METHODOLOGY CURRENTLY USED IN BEST MANAGEMENT PRACTICES

Best Management Practices, previously defined, are directed toward clean up within the dock working area and control of water and wastewater flows into and out of the dock. Wide differences are found between facilities and conditions in facilities, and as a result of these differences, Best Management as practiced at one dock may be either inadequate or unnecessarily extensive if applied to another dock.

Any attempt to define a total cost of Best Management and to apply this to specific facilities is misleading because of the differences encountered. A preferred approach to defining cost is to evaluate costs of individual operations, which can be applied in Best Management Practices, and normalize these to a standard application time, or extent. From such data the costs of Best Management can then be synthesized for individual docks depending upon the specific operations of Best Management required and the time or extent of these operations. This approach admittedly will not permit an exact definition of costs because the components going into the values will not account for variations between facilities, for example labor rates. However, it will be possible to compare the costs attributed to different degrees of Best Management Practices for any given facility and to determine combinations of operations which may achieve equivalent results at reduced expenditures.

Only costs associated with routine clean-up operations of Best Management Practices are considered here. Costs resulting from events such as oil and paint spills are not due to normal operations and are not incurred on a regular basis. The operations considered, in principal, can be applied in any facility but all would not necessarily be applied at any given facility.

The cost of segregation and control of water and wastewater flows is not addressed. Most such efforts require structural modifications to the facility. This aspect of Best Management Practices is dock specific. Differences in facility ages, construction, size and configuration, and geologic and meteorologic conditions prohibit any valid effort to generalize with respect to costs of modifications needed to achieve water and wastewater segregation and control.

Clean-up operations for which costs are estimated here include both mechanical and manual techniques. Mechanical operations use front loaders, sweepers, backhoes, vacuum equipment, and closed cycle blasting. Worker use of shovels, brooms, and hoses are manual operations and in some cases are needed in combination with mechanical methods.

UNIT COSTS OF BEST MANAGEMENT PRACTICES

The elements of cost which combine to make up the costs associated with Best Management Practices include capital investment and depreciation, operating and maintenance costs for equipment, labor costs (with overhead), and contract costs where contractual arrangements are made. When equipment is used for multiple purposes, only one of which relates to the clean-up operations, the cost attributed to management practices must be prorated on the basis of the fractional time so used.

The approach used in this section has been to define the costs associated with methodologies used for clean up. These costs have been normalized to one eight-hour shift. For comparing various techniques which may be used in an existing facility, the unit costs per shift will be multiplied by the number of shifts required for the cleanup cycle.

Clean-up techniques and methodologies included in this breakdown involve use of front loader, mechanical sweeper, vacuum equipment, and backhoe operations. Labor costs for support of these operations, as opposed to the direct operation costs, are separately identified and in most instances represent manual operations when considered alone. Disposal costs are estimated on the basis of unit volume.

Table VIII-1 summarizes the clean-up methodologies which may be used to implement Best Management Practices. The applicability of each method is shown. Where the cost of equipment or method varied due to the presence of raised bilge block slides, two entries have been made to allow for this effect. This has been done because of the higher maintenance costs and life of mechanical equipment subjected to operation over raised bilge block slides. Under these conditions, depreciation over a three year period is used as opposed to eight years for service in a dock having a smooth floor.

Table VIII-2 shows an estimated cost of solid waste removal from shipyards.

Table VIII-1. GERT COSTS OF SELECTED OPERATIONS WHICH MAY BE USED IN BEST MANAGEMENT PRACTICES

| | Large Front Loader | | Small Front Loader | | Mechanical Sweepers | | | Supporting Crane Operations | | |
|---|---|---------------------------|--------------------|---------------------------|-------------------------------------|-------------------------------------|--|-------------------------------|----------|--|
| | Smooth Dock Floor | Raised Bilge Block Slides | Smooth Dock Floor | Raised Bilge Block Slides | Large | Small | Backhoe | | | |
| Capital Equipment Cost | \$15,000 | \$15,000 | \$8,000 | \$8,000 | \$35,000 | \$3,000 | \$15,000 | NA | | |
| Depreciation Period, Yrs | 0 | 1 | 0 | 3 | 0 | 0 | 8 | NA | | |
| Annual Depreciation | \$ 1,875 | \$ 5,000 | \$1,000 | \$2,667 | \$ 4,375 | \$ 375 | \$ 1,075 | NA | | |
| Depreciation Chargeable to one 8 hr shift | \$ 1.71 | \$ 4.57 | \$0.91 | \$2.44 | \$ 4.00 | \$0.34 | \$ 1.71 | NA | | |
| Operating Labor | | | | | | | | | | |
| Skill Level | Operator | Operator | Operator | Operator | Operator | Operator | Operator | Operator | Rigger | |
| Number of Operators | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | |
| Hourly Rate with Overhead | \$11.80 | \$11.80 | \$11.80 | \$11.80 | \$11.80 | \$11.80 | \$11.80 | \$ 17.00 | \$ 10.0 | |
| Cost per 8 hr shift | \$94.40 | \$94.40 | \$94.40 | \$94.40 | \$94.40 | \$94.40 | \$94.40 | \$136.00 | \$160.00 | |
| Operating and Maintenance Cost | | | | | | | | | | |
| Annual Maintenance | \$ 1,500 | \$ 3,000 | \$ 800 | \$ 1,600 | \$ 5,250 | \$ 600 | \$ 2,250 | NA | | |
| Maintenance Chargeable to one 8 hr shift | \$ 1.37 | \$ 2.74 | \$ 0.73 | \$ 1.46 | \$ 4.79 | \$ 0.55 | \$ 2.05 | NA | | |
| Fuel, Oil, etc. per 8 hr shift | \$20.00 | \$20.00 | \$13.00 | \$13.00 | \$26.00 | \$13.00 | \$13.00 | NA | | |
| Cost of Operation | \$117.48/Shift | \$121.71/Shift | \$109.04/Shift | \$111.30/Shift | \$129.19/Shift | \$108.29/Shift | \$111.16 | \$37.00/hr | | |
| Purpose of Operation | Cleanup of Debris | | Cleanup of Debris | | Cleanup of Spent Paint and Abrasive | Cleanup of Spent Paint and Abrasive | Cleanup of Debris from Drainage Trenches | Move Equipment and Containers | | |
| Additional Support Services Required, Not Included in Cost of Operation | Shovellers, Crane | Shovellers, Crane | Shovellers, Crane | Shovellers, Crane | Crane | Crane | Crane | NA | | |
| | Manual Support Operations | | | | | Tunnel Cleanout | | | | |
| | <u>Shoveling</u> | <u>Sweeping</u> | <u>Hosing</u> | | <u>Preparation</u> | <u>Cleanout</u> | | | | |
| Operating Labor Costs | | | | | | | | | | |
| Skill Level | Shovelers | Sweepers | Nozzle men | Assistants | Electrical/Mechanical | Shovelers | | | | |
| Number of Operators | 1 | 1 | 2 | 2 | 4 | 5 | | | | |
| Hourly Rate with Overhead | \$8.90 | \$8.90 | \$8.90 | \$8.90 | \$9.00 | \$8.90 | | | | |
| Cost per 8 hr shift | \$71.20 | \$71.20 | \$142.40 | \$142.40 | \$288.00 | \$356.00 | | | | |
| Cost of Operation | \$71.20/Shift | \$71.20/Shift | \$284.80/Shift | | \$288.00/Shift | \$356.00/Shift | | | | |
| Purpose of Operation | Cleanup of Spent Paint and Abrasive from Dock Floor | | | | Lighting and Ventilation in Tunnels | | Cleanout of Accumulated Debris from Tunnel | | | |

Note: (1) NA - Not Applicable

(2) Cost data as of March to May, 1976

Table VIII-2. COST OF DISPOSAL OF SOLID WASTE
REMOVED FROM DOCKS (INCLUDES HAULING AND LANDFILL FEES)

| | <u>Tons of Debris Per Ship</u> | <u>Volume Cubic Yds</u> | <u>Number of Containers</u> | <u>Total Cost \$ per Clean Up</u> |
|-------------------|--|-----------------------------|---------------------------------|---|
| Light Blasting | 200 | 128 | 8 | 1,000 |
| Heavy | 1,350 | 862 | 53 | 6,625 |

Notes:

1. Cost Data as of March to May, 1976.
2. Bulk Density assumed 116 lb/cu ft.
3. Standard container has 16.4 cubic yard volume.
4. Cost per standard container is \$125 for removal and disposal.

In using the costs presented in Tables VIII-1 and VIII-2 the operations required for best management techniques can be synthesized. Where mechanical equipment has been defined, only the cost of operating the equipment is included. Additional costs resulting from the need for shovellers to work in conjunction with front loaders (or for crane operation to move machinery and collected debris to and from the dock) must be added to define total cost of each operation. Finally, these costs are approximate and do not reflect regional variations, and are based on costs prevailing during the conduct of this study in 1976.

COSTS ATTRIBUTED TO BEST MANAGEMENT PRACTICES VS. ENVIRONMENTAL COSTS

Regardless of other considerations clean up of graving docks and floating drydocks must be performed at some time simply to permit the repair and maintenance operations to be carried out. Some facilities may find frequent clean up a necessary part of their total work effort, while others may routinely go for long time periods between clean up. Cost of clean up performed as normal maintenance cannot be considered environmental charges.

Likewise, the cost of implementing a formal Best Management Practices program cannot be charged entirely to environmental restrictions. Such a program would be directed toward the management objectives, and these are primarily for operational purposes. It is possible that an

actual cost benefit may be realized as a result of a formal program to remove wastes at regular times, but a detailed cost analysis would be necessary to demonstrate the actual effect.

Only two operations have been identified which, in some instances, may represent environmental costs: (1) implementation of a management program requiring clean up at a frequency in great excess of that necessary to achieve Best Management Practices, (2) costs incurred as a result of special solids disposal methods required solely for environmental protection.

In the first of these, only such costs resulting from the excess practices imposed could be related to environmental concern. In the more probable case such a program would be adopted at the discretion of the facility management. Only where local regulations may be stringent enough to force this type of program could part of it be attributed to protecting the environment.

The second example is more clear cut. In general contractual arrangements are in force for ultimate disposal of abrasive blasting debris. This material most frequently is landfilled. Many landfills are regulated to prevent contamination of ground and surface waters by the materials disposed of in them. Some are not. It may be necessary, in certain cases, to alter disposal practices by changing to certified landfills in order to prevent potential damage to groundwater by leaching constituents from abrasive blasting debris. In particular, the disposal of organotin-based debris has been controlled by Naval policies which require that it be sealed in steel drums. Costs resulting from these practices may be considered environmentally incurred.

In summary, shipyards which are currently operating under Best Management Practices programs probably will experience no adverse effects in terms of excessive costs or reduced operations. Where increased effort is necessary by other shipyards to achieve Best Management Practices, minor effects may be noted.

SECTION IX

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SECTION X

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SECTION XI

GLOSSARY

Anticorrosive paints - the initial layer(s) of paint on a ship's hull. The purpose of these paints is to prevent rusting.

Antifouling paints - the final layer(s) of paint applied to a ship's hull. They inhibit the growth of marine organisms on a ship's hull.

Bare Metal - hull metal that has had all paint and marine organisms abraded in preparation for repainting.

Building Basins - a graving dock used solely for ship construction.

Bilge water - water and oil that collects in the lower hull.

Bilge blocks - side blocks placed on the drydock floor. They are located according to the dimensions specific to a particular ship and help stabilize and support the drydocked ship.

Bilge block slides - raised lateral tracks built into many older docks, used to move and position bilge blocks.

Broomed clean - see "Scraped or Broomed clean".

Closed cycle blaster - a type of abrasive blaster that reuses abrasive, usually steel shot, and often collects removed paint and marine organisms.

Cooling water - non-potable water used for shipboard purposes such as air-conditioning and condenser cooling during the drydocked period.

Deflooding - the pumping out of the flooded (filled) drydocks.

Dewatering - see deflooding.

Dock leakage - hydrostatic relief water, gate seepage, and other water leakage other than ship originating wastes that leak into the dock floor.

Drainage discharge - the daily effluent from a drydock. This does not include deflooding water.

Dregs - silt, grit, or other particles deposited on a dock floor during dewatering.

Dry abrasive blasting - a process to remove paint, rust, and marine organisms from a ship's hull. The abrasive usually a copper slag or sand, is conveyed in a medium of high pressure air through a nozzle.

Drydock - either a graving dock or a floating drydock. Also to place a ship in drydock.

Flap gate - a rigid one piece gate hanged at the bottom.

Floating - raising of a submerged floating drydock.

Floating caisson gate - the most common type of graving dock gate. It is floatable and can be moved to permit entry and departure of the ship.

Floating drydock - a submersible moveable platform to enable repairs and maintenance of ships out of water.

Flooded dock - the filled dock following flooding.

Flooding - the filling of a graving dock with water to permit entry or departure of a ship.

Flush deck construction - a flat dock floor not having permanent bilge block slides.

Fresh grit - unused abrasive.

Front loaders - a type of machinery, similar to a bull dozer used to scrap collect and transfer spent paint, grit and marine organisms that collect on the dock floor during blasting.

Gate - the closure that separates a graving dock from the harbor. It is removed to permit entry and departure of the ship.

Graving dock - a dry basin, below water level that is used for repair and maintenance of ships.

Grit - abrasive.

Hydroblasting - the use of a high pressure water stream to remove paint, rust, and marine organisms from a ship's hull.

Hydrostatic relief - the water that leaks into a dock through holes and cracks in the floors and walls of a graving dock. This equilibrates groundwater pressure.

Keel blocks - blocks positioned on the floor of the dock, fitted to match the keel surface of the ship. The drydocked ship is positioned on the blocks.

Launch water - the water in a flooded graving dock.

Manual clean up - use of shovels, brooms, and other equipment which is not power operated to clean the dock floor.

Mechanical clean up - use of machinery, such as front end loaders, mechanical sweepers, or vacuum cleaners to clean the dock floor.

Miter gate - a pair of gate leaves, hinged at the dock walls which swing open to allow passage of a ship into and from a graving dock.

Primer - see "anticorrosive paints."

Sand - often used to describe any dry abrasive.

Sand blast - dry abrasive blasting.

Sand sweep - a light dry abrasive blast used to remove only the outer layers of paint and marine growth from a ships hull.

"Scraped or Broomed Clean" - using shovels, mechanical loaders, mechanical sweepers, or brooms to remove abrasive blasting debris.

Scupper boxes - containers used to collect water that runs off a ship deck.

Shipboard wastes - all effluent discharges originating from a drydocked ship. Included are sanitary wastes, bilge water, cooling water, and cleaning wastes.

Sinking - flooding of caissons and lowering of floating drydock to permit a ship to be positioned over the dock prior to floating of the dock and docking.

Slurry blasting - see "wet abrasive blasting."

Soil chutes - flexible hoses, usually made of rubber coated nylon or canvas used to transfer shipboard wastes from the docked vessel to the appropriate disposal system.

Spent abrasive - used grit and spent paint, rust, and marine organisms that collect on the dock floor during blasting.

Stripping - see "drainage discharge."

Wash down - the hosing down of the dock, and sides of the ship following docking to remove silt, marine organisms, etc.

Water cone abrasive blasting - a type of blasting that uses a cone of water to surround the stream of air and abrasive as they leave the nozzle.

Wet abrasive blasting - a process to remove paint, rust, and marine growth from ship's hulls, in which high pressure water propels an abrasive.

White metal - see "bare metal."

TABLE
METRIC TABLE
CONVERSION TABLE

| MULTIPLY (ENGLISH UNITS) | | by | TO OBTAIN (METRIC UNITS) | |
|----------------------------|--------------|--------------------|--------------------------|-----------------------------|
| ENGLISH UNIT | ABBREVIATION | CONVERSION | ABBREVIATION | METRIC UNIT |
| acre | ac | 0.405 | ha | hectares |
| acre - feet | ac ft | 1233.5 | cu m | cubic meters |
| British Thermal Unit | BTU | 0.252 | kg cal | kilogram - calories |
| British Thermal Unit/pound | BTU/lb | 0.555 | kg cal/kg | kilogram calories/kilogram |
| cubic feet/minute | cfm | 0.028 | cu m/min | cubic meters/minute |
| cubic feet/second | cfs | 1.7 | cu m/min | cubic meters/minute |
| cubic feet | cu ft | 0.028 | cu m | cubic meters |
| cubic feet | cu ft | 28.32 | l | liters |
| cubic inches | cu in | 16.39 | cu cm | cubic centimeters |
| degree Fahrenheit | °F | 0.555(*F-32)* | °C | degree Centigrade |
| feet | ft | 0.3048 | m | meters |
| gallon | gal | 3.785 | l | liters |
| gallon/minute | gpm | 0.0631 | l/sec | liters/second |
| horsepower | hp | 0.7457 | kw | kilowatts |
| inches | in | 2.54 | cm | centimeters |
| inches of mercury | in Hg | 0.03342 | atm | atmospheres |
| pounds | lb | 0.454 | kg | kilograms |
| million gallons/day | mgd | 3,785 | cu m/day | cubic meters/day |
| mile | mi | 1.609 | km | kilometer |
| pound/square inch (gauge) | psig | (0.06805 psig +1)* | atm | atmospheres (absolute) |
| square feet | sq ft | 0.0929 | sq m | square meters |
| square inches | sq in | 6.452 | sq cm | square centimeters |
| ton (short) | ton | 0.907 | kg | metric ton (1000 kilograms) |
| yard | yd | 0.9144 | m | meter |

* Actual conversion, not a multiplier

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POLYCHLORINATED BIPHENYLS

1929 - 1979:

FINAL REPORT



May 1979

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Toxic Substances
Washington, D. C. 20460

This document is available in limited quantities through the U. S. Environmental Protection Agency, Industry Assistance Office, Office of Toxic Substances (TS-793), 401 M Street, S.W., Washington, D.C. 20460.

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POLYCHLORINATED BIPHENYLS 1929-1979 :

FINAL REPORT

Final Report

Submitted to:

U.S. Environmental Protection Agency
Office of Toxic Substances
Washington, D.C. 20460

Attention: Mr. Thomas E. Kopp
Project Officer

Contract No. 68-01-3259

Submitted by:

VERSAR, INC.
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Springfield, Virginia 22151
(703) 750-3000

May 16, 1979

This report has been reviewed by the Office of Toxic Substances, U. S. Environmental Protection Agency, and approved for publication. Approval does not necessarily signify that the contents reflect the views and policies of the Environmental Protection Agency, nor does mention of tradenames or commercial products constitute endorsement or recommendation for use.

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PREFACE

This report summarizes the work on Polychlorinated Biphenyls (PCBs) that Versar performed for the U.S. Environmental Protection Agency under Contract No. 68-01-3259. Mr. Thomas E. Kopp was the Program Manager for the EPA throughout the performance of this work, and his patient support is gratefully acknowledged.

PCBs were first manufactured in commercial quantities in the U.S. in 1930, and during the next 40 years they were widely used as solvents, resins, and electrical dielectric liquids. Recognition of their environmental persistence and toxicity in the late 1960's eventually led to a ban on the manufacture and use of PCBs in the Toxic Substances Control Act of 1976. This report summarizes the use of PCBs and much of the early literature on the uses and toxicity of this material. In addition, the report reviews the regulatory actions that have been taken to limit the hazards to health and the environment resulting from the accumulation of PCBs in the environment and from their continued use in certain electrical equipment. The report is primarily a summary of the reports that Versar has prepared in support of the EPA's regulatory activities involving PCBs.

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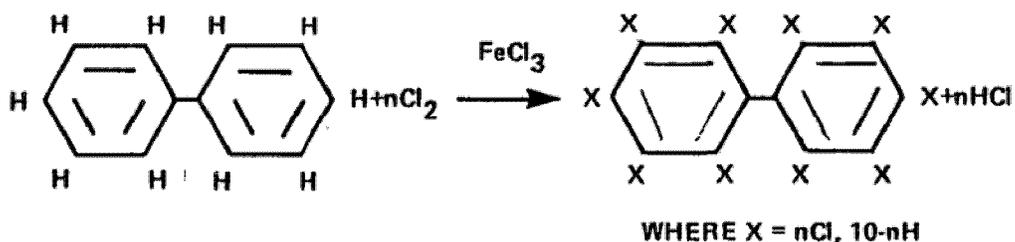
1.0 INTRODUCTION

On June 26, 1975, the U.S. Environmental Protection Agency awarded contract no. 68-01-3259 to Versar, Inc. Under this contract, it was anticipated that Versar would be assigned a number of tasks to assess the micro-economic impacts of regulatory alternatives which the EPA would consider for various toxic substances. The first task assigned under this contract required Versar to review and summarize the existing data on the use of polychlorinated biphenyls and to identify the industrial segments that might be impacted by regulations limiting the use of PCBs.

Before this task was completed, PCBs became a major issue within EPA, and the scope of the work assigned to Versar was increased as the agency required additional support. This report summarizes the work that Versar performed over the next four years for the EPA under the subject contract and a follow-on contract that was closely related to this work. All of this work supported regulatory activities involving PCBs, so the description of the work performed necessarily includes a history of the use of PCBs, a summary of regulatory development, and references to related research and reports.

2.0 POLYCHLORINATED BIPHENYLS

Polychlorinated biphenyls are a group of related compounds formed by the addition of chlorine to the aromatic hydrocarbon "biphenyl." The reaction can be described by the following equation:



2.1 History of PCB Usage:

PCBs were first synthesized and described in 1881 (Schmidt, 1881). Commercial production of PCBs did not become possible until after an economical method was developed during the 1920s for the manufacture of biphenyl from benzene.

Biphenyls were first produced in commercial quantities in the U. S. by Swann Research, Inc., of Anniston, Alabama. Shortly after they started manufacturing biphenyls, Swann Research described the manufacturing process (Jenkins, 1930) and the properties of the PCBs they were marketing under the tradename Aroclor (Penning, 1930). The various Aroclors were described as mixtures of chlorinated diphenyls with a wide range of properties from a light oil to a hard resin depending on the degree of chlorination. A number of commercial applications were suggested, including use in varnish, as a fireproofing agent for wood, in electrical equipment as a liquid dielectric and as a component of electrical insulation, as an ingredient in adhesives, as a replacement for Canada Balsam in microscopy, as a substitute for chicle in chewing gum, and in miscellaneous uses including printing inks and textile finishing (Penning 1930). A separate technical article described the compatibility of PCBs in nitrocellulose lacquer resins (Jenkins, 1931). The first major use of PCBs was apparently as a liquid dielectric in capacitors manufactured by General Electric Co. starting in 1930 (Clark, 1962). General Electric also developed the use of PCBs in other electrical applications as described in articles published during the 1930s (Clark, 1934; Clark, 1937).

PCBs were manufactured at the Anniston, Alabama, plant by Swann Research, Inc. and its corporate successor, Monsanto Chemicals Co., until the plant was shut down in 1971. Monsanto also manufactured PCBs at its plant at Sauget, Illinois, until 1977. The only other known U. S. manufacturer of PCBs was Geneva Industries of Houston, Texas, which manufactured PCBs for heat transfer applications from 1972 through 1974.

Most of the applications of PCBs that had been suggested in 1930 proved to be successful. PCBs were used as heat transfer liquids in critical applications such as food processing (Smith, 1955; Coulson, 1957), in various electrical applications (Clark, 1962), in sealants (Skrentny, 1971), in carbonless copy papers (Masuda, 1972; Lister, 1972), and in paint (Young, 1974). Polychlorinated terphenyls were suggested as a carrier for insecticides (Tsao, 1953; Sullivan, 1953). A Monsanto marketing guide to PCBs which was published in the late 1960s also described their possible use as expansion media in temperature sensing bellows devices, as liquid sealants for furnace roofs, as sealers for

gaskets, as dedusting agents, in insecticides, in casting waxes, in abrasives, in lubricants and cutting oils, in adhesives, in polishing waxes and impregnating compounds, in coatings, in inks, in mastics, in sealing and caulking compounds, in tack coatings, and as plasticizers in plastics, paint, varnish, and lacquer. (Monsanto, undated). In addition, a number of other uses of PCBs had been patented over the years (for a list of patents see: Interdepartmental Task Force on PCBs, 1972, pp. 70-74).

The available data on the toxicity of PCBs was first summarized in an article published in 1931 (Smyth, 1931). Skin problems attributed to PCB exposure were later reported to be associated with various industrial processes including PCB manufacturing (Jones, 1936), capacitor manufacturing (Mayers, 1936), industrial painting (Birmingham, 1942), and electrical cable insulating (Good, 1943). Systemic effects of exposure to mixtures of chlorinated organic compounds including PCBs were also noted during the 1930s (Drinker, 1937) and were evaluated by animal exposure studies (Bennett, 1938; von Wedel, 1943; Miller, 1944.) In much of this early work, the toxicity studies used commercial mixtures which included chlorinated naphthalenes, and the effects of PCBs were not conclusively demonstrated (Drinker, 1939). Animal exposure tests eventually defined the toxicity of PCBs (Treon, 1946; McLaughlin, 1963; American Industrial Hygiene Assoc., 1965), and reports of worker health problems became limited to unusual situations (i.e., Meigs, 1954). Information on the toxicity of PCBs led the investigation of PCBs as a possible cause of chick edema disease (McCune, 1962; Flick, 1965) which was later demonstrated to be caused by contamination of feed with chlorinated dibenzodioxins.

During the early 1960s interest increased concerning the biological effects of environmental levels of chlorinated pesticide residues such as DDT and chlordane. Measurement of low levels of these compounds in biological samples required the development of sensitive analytical procedures that could both separate the pesticides from each other and from similar compounds and measure the amount of each compound present. The technique that was developed to perform this analysis was gas chromatography. In this method, a small amount of sample is introduced into a long heated tube which is packed with a material that has

different adsorption characteristics for the different compounds in the sample. The tube is then flushed with an inert gas, and the different compounds are swept out of the tube at different times past a detector that is sensitive to the presence of chlorinated organic compounds and that gives a response proportional to the amount of chlorinated material in the stream of inert gas. The time required for each compound to move through the tube depends on the temperature, the type of packing, the rate of flushing with inert gas, and the characteristics of the particular compound. Therefore, the identification of the compounds in the environmental sample depends on knowing the retention time of the compounds and the response of the detector to each compound. This requires that known compounds be run through the column and detector, and as a result, only known compounds can be identified. Gas chromatography proved to be a very useful method for determining the concentrations of low levels of pesticides in environmental samples, but the detector usually recorded the presence of a number of chemicals that could not be identified by comparison with known pesticide chemicals.

In 1966, Soren Jensen attempted to identify the unknown compounds that were being recorded during routine pesticide analyses. In order to determine when the unknown compounds first appeared in biological samples, he analyzed feathers, from eagles that had been taken for museum collections. He found the unknown materials in feathers collected as early as 1944, before the widespread use of chlorinated pesticides, and so concluded that the unknown materials were not pesticides or degradation products of pesticides (Jensen, 1972). By testing chlorinated materials that were in wide use before 1944, he eventually identified commercial PCBs as the source of the unknown compounds, and published this finding in late 1966 (Jensen, 1966).

A full discussion of the presence of PCBs in pesticide analyses was published in 1967 (Widmark, 1967), and this set off a number of investigations to determine the extent of environmental contamination by PCBs. The discovery that PCBs were common in the environment in sufficient concentrations to affect the reproduction of wild birds was published in 1968 (Risebrough, 1968). This article was picked up in the press which started the widespread concern about possible human health effects from PCBs in the environment.

The Yusho incident that occurred in Japan during the summer of 1968 added to the public concern over the toxicity of PCBs. This was a case of widespread PCB poisoning caused by contamination of cooking oil. The PCBs were used a heat transfer liquid on the high temperature side of a heat exchanger used to pasturize the oil. Over 1000 people were seriously affected by eating contaminated oil (Kuratsune, 1971). The resulting concern over PCBs led to regulatory activity and increased research throughout the world. In July of 1971, a similar incident in the United States contaminated a considerable quantity of chicken feed as the result of leakage of PCB heat transfer fluid. The U.S. Food and Drug Administration eventually destroyed thousands of chickens and eggs that were fed this contaminated feed (Pichirallo, 1971). Starting in 1970, Monsanto voluntarily limited sales of PCBs to closed electrical equipment applications (Wood, 1975) and recommended that existing PCB-filled heat transfer systems be drained and refilled with non-PCB fluid (Monsanto, 1972). This voluntary ban was completed by the end of 1973. Monsanto closed the Anniston, Alabama, manufacturing plant at this time.

By 1972, a great deal of research had been completed on PCBs and was summarized in various review articles covering their toxicity (Kimbrough, 1972; Kimbrough, 1974), environmental impact (Peakall, 1972; Hammond, 1972), environmental distribution (Nisbet, 1972), uses (Broadhurst, 1972), presence in food (Fries, 1972) and chemical analysis (Reynolds, 1971). The basic information on PCBs was later compiled in the monograph "The Chemistry of PCBs" (Hutzinger, 1974). The amount of published information on PCBs has continued to grow rapidly since the early 1970s and is now most accessible through published literature surveys (Fuller, 1976; Kornreich, 1976) and annotated bibliographies (Quinby, 1972; Office of Water Resources Research, 1973; Office of Water Research and Technology, 1975; Cavagnaro, 1978).

2.2 PCB Use Restrictions and Government Regulations

The Yusho incident created considerable concern in the U. S. over possible contamination of food by PCBs. The U. S. Food and Drug Administration started routine sampling of foods for PCBs in 1969, and soon found that PCBs

were present in fish from the Great Lakes, that there was PCB contamination of milk caused by use of PCBs as a solvent in pesticide sprays and as a component of sealants used in farm silos, and that there was contamination of chickens resulting from PCBs introduced into the feed as a component of ground bread cartons and wrappers. It has since become apparent that the presence of PCBs in fish is a problem that has existed since at least 1964 (Hartsough, 1965), although PCBs were not identified as the cause of the problem until 1971 (Aulerich, 1971; Aulerich, 1973).

From 1969 through 1971, the FDA established action levels for PCBs in food at 0.2 ppm in milk, 5 ppm in edible flesh of fish, 5 ppm in poultry, and 0.5 ppm in eggs. In 1970, the FDA prepared a summary of the available information on the chemistry and toxicity of PCBs (U. S. Department of Health, Education, and Welfare, 1970). In 1972, the FDA published a notice of proposed rulemaking (Federal Register, 37FR 5705). The U. S. Department of Agriculture also prepared a report on ways that it could act to limit PCB contamination of Food (U. S. Department of Agriculture Ad Hoc Group on PCBs, 1972.) In 1973, the FDA formally established limits for PCBs in food and animal feed (Federal Register, 38FR 18096). The FDA proposed a revision of these limits in 1977 (Federal Register, 42FR 17487), but no action has yet been taken on this proposal.

During 1970, the Council on Environmental Quality (CEQ) studied regulatory approaches to the problem of toxic chemicals in the environment. In its report "Toxic Substances" published in 1971, CEQ identified PCBs as a major problem (Council on Environmental Quality, 1971). The initial response of the responsible agencies was to establish a task force to review the available information on PCBs and recommend regulatory alternatives (Interdepartmental Task Force on PCBs, 1972).

During 1973 and 1974, the EPA proposed the establishment of water quality criteria for PCBs in industrial discharges as part of a program for establishing such criteria for a larger group of pesticides. However, PCBs were not covered in the effluent standards that were eventually promulgated.

The Occupational Safety and Health Administration adopted the standards for PCB exposure in industrial air that had previously been established by the American Industrial Hygiene Association. The National Institute of Occupational Safety and Health conducted a major review of available data and an extensive program of industry assessment in the mid 1970s, and the final report recommended that the allowable concentration of PCBs in the work place be reduced (NIOSH, 1977). However, OSHA has not yet taken action on this recommendation.

Government actions restricting the use of PCBs were not limited to the United States. Japan banned the manufacture and use of PCBs in the early 1970s because of public pressure following the Yusho incident. Sweden banned the use of PCBs at about the same time. International actions were also taken to reduce the risk of food contamination by PCBs during the early 1970s (OCED, 1973; OECD Council, 1973; The Council of the European Communities, 1976).

3.0 CONTRACT SUPPORT OF EPA ACTIONS ON PCBs

3.1 Support of Office of Toxic Substances

During 1974 and 1975, the Office of Toxic Substances sponsored a series of review studies to identify regulatory alternatives for various specified toxic substances. Contract 68-01-3259 was awarded by the EPA to Versar on June 26, 1975, to support similar work on additional chemicals. The first task on this new contract was assigned by the EPA Technical Project Officer, Mr. David Garrett, on June 27, 1975. This task required the contractor to study the role of PCBs in the U.S. economy and prepare a draft report by October 31, 1975, identifying and screening alternative regulatory and non-regulatory control options: Study of Regulatory Alternatives for PCBs: Draft Interim Report - Task I, October 31. (Unpublished - Superseded by "PCBs in the United States...")

As part of the review of PCBs, the Office of Toxic Substances sponsored a national conference on PCBs in Chicago on November 19 thru 21, 1975.

The Technical Coordinator of this conference was Mr. Thomas Kopp of the Office of Toxic Substances. Several major articles on the environmental effects of PCBs that appeared in the popular press shortly before the conference (Boyle, 1975a; Boyle, 1975b) caused considerable public interest in the conference and a number of demands that EPA regulate PCBs. Dr. Robert Durfee of Versar participated in this conference and presented a paper summarizing the background on PCBs as presented in the draft report (Durfee, 1975).

Because of the increasing importance of PCBs to the activities of the Office of Toxic Substances after the conference, the EPA assigned Mr. Kopp as Technical Project Officer on the contract and had the contractor expand the draft interim report and prepare four special reports under Task I. The Versar Program Manager in charge of this work was Dr. Robert Durfee. The following reports were submitted in response to this directive:

The Handling and Disposal of Electric Transformers: Special Report, Task I (December 5, 1975). Non-proprietary sections included in "PCBs in the United States...."

Results from Review and Analysis of 308 Letter Responses on PCB Manufacturing, Usage, and Disposal in United States Industry: Special Report (December, 1975).

- * Toxicological Studies Conducted Under Task I: Special Report (February 19, 1976). Incorporated in "PCBs in the United States..." as Appendix F.
- * Development of an Economic Analysis Methodology for Evaluating Regulatory Alternatives for PCBs: Special Report, Task I (March 9, 1976). Unpublished.
- * PCBs in the United States: Industrial Use and Environmental Distribution Final Report, Task I (February 25, 1976). EPA 560/6-76-005. NTIS PB 252 012.

At about the same time that Task I was expanded, the EPA directed the contractor to perform two additional tasks. Task II was a study of wastewater treatment technology that could be used to reduce the concentration of PCBs in industrial effluents. This work was supported by Clark, Dietz Associates who performed the industrial economic analysis under subcontract from Versar as provided by Modification 1 to the contract. Task III was a plan for an assessment of the use of PCBs

*See summary of report in Appendix C.

in the investment casting industry and the resulting environmental impacts. Versar program managers were Mr. Donald Sargent on Task II and Dr. Robert Durfee on Task III. The following reports were submitted in response to these work directives:

- * Assessment of Wastewater Management, Treatment Technology, and Associated Cost for Abatement of PCBs Concentration in Industrial Effluents: Final Report, Task II. (February 3, 1976). EPA 560/6-76-006. NTIS PB 251-433/AS.
- * Development of a Study Plan for Definition of PCBs Usage, Wastes, and Potential Substitution in the Investment Casting Industry: Final Report, Task III. (January, 1976) EPA 560/6-76-007. NTIS PB 251-842.

Based on these three tasks and on other work performed within the Environmental Protection Agency, the EPA published recommended disposal procedures for PCBs (Federal Register, 41 FR 14134) and proposed effluent standards for PCBs in the water discharges from PCB manufacturers and from capacitor and transformer manufacturers that used PCBs (Federal Register, 41 FR 30468).

Senator Gaylord Nelson introduced an amendment to the Toxic Substances Control Act (TSCA) on March 26, 1976. This amendment required the EPA to establish labeling and disposal requirements for PCBs and mandated an eventual ban on the manufacture and processing of PCBs. This amendment was incorporated into TSCA as Section 6(e) and became a legislated requirement when TSCA was signed into law on October 11, 1976. The effective date of TSCA was January 1, 1977.

On July 15, 1976, EPA modified the contract to support additional studies on several aspects of PCBs. EPA technical supervision of this work was the responsibility of Mr. Kopp. Under this contract modification (Mod. 4), four formal tasks were established and two additional reports were prepared for internal EPA use. The Versar program manager for this work was Mr. Robert Westin, with each report being the responsibility of a Versar Task Manager who was as the principal author of the report. The following reports were submitted in response to the requirements of this contract modification:

*See summary of report in Appendix C.

- * PCBs Involvement in the Pulp and Paper Industry: Final Report, Task IV.
EPA 560/6-77-005, NTIS PB 271-071/6WP. February 25, 1977.
- * A First Order Mass Balance Model for the Sources, Distribution, and Fate of PCBs in the Environment: Final Report, Task V.
EPA 560/6-77-006, NTIS PB 270-220. July, 1977.
- * Assessment of the Environmental and Economic Impacts of the Ban on Imports of PCBs: Final Report, Task VI. EPA 560/6-77-007, NTIS PB 270-225. July 1977.
- * Assessment of the Use of Selected Replacement Fluids for PCBs in Electrical Equipment: Final Report, Task VII. EPA 560/6-77-008, NTIS No. forthcoming. April, 1979.

Environmental Discharges of PCBs Associated with the Manufacture and Use of PCBs and PCB-Containing Equipment. (Contains EPA proprietary information, submitted to EPA Enforcement Division.) October 29, 1976.

Usage of PCBs in Open and Semi-Closed Systems and the Resulting Losses of PCBs to the Environment. (Contains EPA proprietary information, submitted to EPA Enforcement Division.) September 30, 1976.

3.2 Support of the Criteria and Standards Division

Versar provided support to the Criteria and Standards Division of EPA under three separate contract modifications. All of the work involved support of the effluent standards for PCBs by performing additional technical and economic analysis of the feasibility and costs of various pollution abatement technologies. The EPA Technical Program Manager on this work was Mr. Thomas Kopp, and the EPA Task Manager was Mr. Ralph Holtje of the Criteria and Standards Division. The Versar Program Manager was Mr. Donald Sargent. The contract modification requirements and the reports submitted were as follows:

Modification 2 (Feb. 27, 1976): Provided for the analysis of the economic impacts of the proposed regulation by Jack Faucett Associates under subcontract from Versar and for the review of the Final Task II report by Versar.

*See summary of report in Appendix C.

- * PCBs Water Elimination/Reduction Technology and Associated Costs: Manufacturers of Electrical Capacitors and Transformers: Addendum to Final Report, Task II. EPA 440/9-76-020. July 2, 1976.

Recommendations as to PCB Sampling Sites and Sampling Points at Industrial Sources: Special Report. August 17, 1976.

- * Economic Analysis of Proposed Toxic Pollutant Effluent Standards for Polychlorinated Biphenyls: Transformer, Capacitor, and PCB Manufacturing. (Prepared by Jack Faucett Associates) EPA 230/1-76-068. October, 1976.

Modification 3 (June 10, 1976): Provided for additional assessment of wastewater management and treatment technology and support of EPA during formal hearings and rulemaking proceedings.

- * Costs for U.V. - Ozonation Process: Addendum to Final Report, Task II. September 27, 1976. Unpublished.

- * Detailed Cost Estimates for Alternative PCBs Treatment Technologies Applied to Hypothetical Large and Medium Sized PCB Capacitor and Transformer Manufacturing Plants. Addendum to Final Report, Task II. October 15, 1976. Unpublished.

- * Cost for Equalization Basin Based on Bentonite Clay Liner Special Report, October, 1976. Unpublished.

- * Impacts of Substitutes for PCBs on Fire Hazards in Commercial and Residential Buildings: (Draft) Special Report. October, 1976. Unpublished.

- * Recent Advances in PCBs Detoxification in Wastewater: Supplement to Final Report, Task II. January 18, 1977. Unpublished.

- * PCB Levels in Non-Contact Cooling Waters and Other Effluents from Capacitor and Transformer Production Facilities: Supplement to Final Report, Task II. January 18, 1977. Unpublished.

- * Refinement of Alternative Technologies and Estimated Costs for Reduction of PCBs in Industrial Wastewaters from the Capacitor and Transformer Manufacturing Categories. January 19, 1977. Unpublished.

- * Costs Associated with Installing Production Equipment for Use of Non-PCB Dielectric Fluids in Transformer and Capacitor Manufacture: Supplement to Final Report, Task II. January 19, 1977. Unpublished.

*See summary of report in Appendix C.

On February 2, 1977, the EPA promulgated effluent standards restricting any discharges of PCBs in the wastewaters from manufacturers of PCBs or from capacitor and transformer manufacturing plants that used PCBs after February 2, 1978 (Federal Register, 42 FR6531).

3.3 Support of PCB Work Group - Disposal and Marking Regulations

Section 6(e)(1) of the Toxic Substances Control Act required the EPA to regulate the labeling and disposal of PCBs by July 1, 1977. On December 8, 1976, the EPA announced the formation of a PCB Work Group to write the proposed rules. The contractor provided staff support to this work group, providing a number of special reports as requested, performing the economic impact analysis of the proposed regulation, and providing testimony at the rulemaking hearing. The contract was modified on March 25, 1977, (Mod. 6) to authorize this additional technical and economic support. The EPA Project Officer for this work was Mr. David Wagner, and Mr. Thomas Kopp remained the Technical Project Officer in charge of the total contract. The Versar Program Manager was Mr. Robert Westin. The following reports were submitted in support of the development of the PCB Marking and Disposal Regulations:

Assessment Methodology for Labeling and Education to Assure the Proper Disposal of PCBs: Special Report. November, 1976.

Analysis of the Economic and Technological Constraints on the Disposal of PCBs: Special Report. November 22, 1976.

PCB Disposal Regulations: Problem Areas and Regulatory Alternatives: Special Report. December 10, 1976.

Estimated Usage of Electrical Equipment Containing PCBs: Special Report. December 23, 1976.

Recommended Label Requirements and Suggested Label Formats: Special Report. January 12, 1977.

Draft Notice of Public Meeting - PCBs. January 10, 1977.

Comments on PCB Definitions to Subcommittee on Manufacturing Bans. January 14, 1977.

*See summary in Appendix C.

Draft Notice of Proposed Rulemaking, Preamble, and Labeling and Disposal Regulations: Special Report. January 21, 1977; revised February 4, 1977.

Labeling and Disposal Regulations: Revised Draft. January 27, 1977.

Draft Preamble to PCB Disposal Regulation. December 29, 1976; revised January 12, 1977; revised February 4, 1977.

Economic Impact - Summary and Conclusions: Special Report. March 14, 1977.

Statement of Economic Consequences of the Rule: Special Report. April 12, 1977.

- * Microeconomic Impacts of the Proposed Marking and Disposal Regulations for PCBs. April, 1977. EPA 560/6-77-013, NTIS PB 267-833.

EPA formally proposed the rules for marking and disposal of PCBs on May 24, 1977 (Federal Register, 42 FR 26564). Rulemaking hearings were held on June 24, 27, 28, and 29. Mr. Westin of Versar presented testimony on the economic impacts of the proposed regulation at the hearings on June 29. The EPA promulgated the PCB Disposal and Marking Regulations on February 17, 1978 (Federal Register, 43 FR 7150) and issued corrections on August 2, 1978 (Federal Register, 43 FR 33918). The effective date of the regulations was April 18, 1978.

3.4 Support of PCB Work Group - PCB Ban Regulations

Sections 6(e)(2) and 6(e)(3) of the Toxic Substances Control Act banned the manufacturing, processing, distribution, and use of PCBs after January 1, 1978, except in a totally enclosed manner; completely banned the manufacture of PCBs after January 1, 1979; and completely banned the processing and distribution in commerce of PCBs after July 1, 1979. However, the Act also authorized the EPA to exempt those activities involving PCBs that did not present an unreasonable risk of injury to health or the environment provided

*See summary in Appendix C.

that good faith efforts were made to develop an adequate substitute for PCBs in that use. On June 27, 1977, the EPA announced the formation of a PCB work group to develop proposed regulations implementing these provisions of the act, and announced public meetings on the subject to be held in Washington, D.C. on July 19, 1977 (Federal Register, 42 FR 32555).

EPA modified the contract on June 26, 1977, (Mod. 7) to provide for support during the development of the proposed ban regulations. EPA Project Officers continued to be Mr. Wagner and Mr. Kopp. Versar's work was supervised by Mr. Westin. Versar prepared briefing papers for the work group prior to the public meetings and submitted them to the work group as the special report: Potential Impacts of the Bans on PCB Manufacturing, Processing, and Use: PCB Activity Analysis Papers (July 11, 1977).^{*} Following the public meetings, the work group prepared a draft of the proposed regulations (August 30, 1977), and the contractor submitted a formal report on the economic impacts of these regulations: Microeconomic Impacts of the Draft "PCB Ban Regulations": Draft Report (September 18, 1977). Formal proposal of the ban regulations was delayed while the Work Group prepared the final version of the Disposal and Marking Regulations, and on December 30, 1977, EPA announced that it would not enforce the January 1, 1978 ban on open system activities involving PCBs until after formal ban regulations were promulgated (Federal Register, 42 FR 65264).

The work group continued to revise the draft proposed regulation, and Versar submitted a major revision of the economic impact analysis reflecting the changes in the proposed regulation and including appendices characterizing the U.S. waste oil industry and presenting a formal microeconomic analysis of the supply and demand effects of the PCB Ban on the electric equipment industry: Microeconomic Impacts of the Draft "PCB Ban Regulations": Revised Draft Report (March 8, 1978).^{*}

3.5 Support of EPA Office of Planning and Management - PCB Ban Regulations

In early 1978, the EPA transferred responsibility for the analysis of the economic impacts of the PCB ban regulations from the PCB Work Group to the

^{*}See summary in Appendix C.

Office of Planning and Management. On April 19, 1978, the EPA awarded contract number 68-01-4771 to Versar for additional economic analysis, preparation of a revision of the previously submitted draft economic impact report, and support during the public hearings on the proposed regulations. The EPA Technical Project Officer was Mr. Steven B. Malkensen, Office of Planning and Management. The Versar Program Manager was Mr. Robert Westin. In May, 1978, the contractor submitted the revised report: Microeconomic Impacts of the Proposed "PCB Ban Regulations"* that was issued in support of the proposed regulations as EPA Report No. EPA-560/6-77-035.

The EPA formally proposed the PCB Ban Regulations on June 7, 1978 (Federal Register, 43 FR 24801). Public Hearings were held in Washington, D. C., from August 21 through September 1, 1978. Mr. Westin of Versar presented testimony on the economic impacts of the proposed regulations on September 26, 1978.

Following the hearings, EPA continued to revise the ban regulations. On November 1, 1978, EPA published interim procedural rules for filing and processing petitions for exemptions from the January 1, 1979 bans on manufacturing of PCBs (Federal Register, 43 FR 50905). On January 2, 1979, EPA announced that it would not enforce the prohibitions on PCB manufacturing, processing, distribution in commerce, and use until after formal promulgation of the PCB Ban Regulations (Federal Register, 44 FR 108).

On November 15, 1978, Versar submitted a draft report on the economic impacts of the draft ban regulations: PCB Manufacturing, Processing, Distribution in Commerce, and Use Ban Regulation: Economic Impact Analysis: Draft Final Report. A major revision of this report was submitted on December 22, 1978. On December 27, 1978, EPA modified contract 68-01-4771 to extend the duration of the contract and to fund further revisions of the economic impact analyses as required by additional changes to the draft regulation. Mr. Stephen Weil was assigned to be the EPA Technical Project Officer for this contract modification. The contractor submitted the final revision of this

*See summary in Appendix C.

report on March 30, 1979.* EPA issued the final regulations on April 19, 1979. Formal promulgation of the regulations through the Federal Register was expected to occur by the end of May, 1979.

*See summary in Appendix C.

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APPENDIX A

FEDERAL REGISTER NOTICES REGARDING PCBs

Environmental Protection AgencyEffluent Limitations (§ 307a Clean Water Act)

| <u>Date</u> | <u>Vol.</u> | <u>Pages</u> | <u>Subject</u> |
|--------------|-------------|--------------|--|
| July 6, 1973 | 38 | 18044-5 | Proposed List of Toxic Pollutants, Including PCBs. |
| Sept 7, 1973 | 38 | 24342-4 | Promulgated List of Toxic Pollutants, Including PCBs. |
| Dec 27, 1973 | 38 | 35388-95 | Proposed Water Effluent Standards, Including PCBs. |
| Mar 5, 1974 | 39 | 8325-6 | Public Hearings on Effluent Standards. |
| Mar 21, 1974 | 39 | 10603-4 | Correction - Effluent Standards. |
| Jul 23, 1976 | 41 | 30468-77 | Proposed Effluent Standards. |
| Feb 2, 1977 | 42 | 6531-55 | Effluent Standard Regulations. |

Spill Reporting Requirements (§ 311, Clean Water Act)

| <u>Date</u> | <u>Vol.</u> | <u>Pages</u> | <u>Subject</u> |
|--------------|-------------|--------------|---|
| Feb 16, 1979 | 44 | 10266 | Definition of "Discharge" under Clean Water Act. |
| Feb 16, 1979 | 44 | 10271-84 | Defines Reportable Quantities of PCBs Spilled into Waterways, Reporting Requirements and Fines. |

Disposal and Marking Regulations (§ 6e1) Toxic Substances Control Act

| <u>Date</u> | <u>Vol.</u> | <u>Pages</u> | <u>Subject</u> |
|--------------|-------------|--------------|---|
| Apr 1, 1976 | 41 | 14134-36 | Recommended Disposal Procedures. |
| Dec 8, 1976 | 41 | 53692 | Panel Discussion/Formation of PCB Work Group. |
| Jan 5, 1977 | 42 | 1067 | Rescheduling of Meeting. |
| Jan 19, 1977 | 42 | 3701-2 | Notice of Jan. 24, 1977 Public Meeting. |
| Apr 21, 1977 | 42 | 20640-44 | Proposed Procedures for Rule-Making under Sect. 6 of TSCA. |
| May 24, 1977 | 42 | 26564-77 | Proposed Marking and Disposal Regulations. |
| Jul 15, 1977 | 42 | 36484-85 | Deadline for Reply Comment Period. |
| Feb 17, 1978 | 43 | 7150-64 | Promulgated Marking and Disposal Regulations. |
| Jul 18, 1978 | 43 | 30882-3 | List of Approved PCB Disposal Facilities. |
| Aug 2, 1978 | 43 | 33918-20 | Corrections to Marking & Disposal Regulations. |
| Aug 25, 1978 | 43 | 38087-88 | List of Approved PCB Disposal Facilities. |
| Oct 26, 1978 | 43 | 50041 | List of Approved PCB Disposal Facilities. |
| Dec 20, 1978 | 43 | 59432-3 | List of Approved PCB Disposal Facilities. |
| Mar 12, 1979 | 44 | 13575 | Request for Comments on Citizens' Petition to Give Regional Administrators Authority to Approve Alternate Disposal Methods. |

Ban Regulations (§ 6e2, 6e3, etc.) Toxic Substances Control Act

| <u>Date</u> | <u>Vol.</u> | <u>Pages</u> | <u>Subject</u> |
|---------------|-------------|--------------|---|
| Jun 27, 1977 | 42 | 32555 | Notice of July 19 Chicago Hearing. |
| Dec 30, 1977 | 42 | 65264 | Notice that EPA Would Not Enforce Ban on Uses in "Other Than a Totally Enclosed Manner." |
| Jun 7, 1978 | 43 | 24802-17 | Proposed Ban Regulations. |
| Jun 7, 1978 | 43 | 24818 | Requires Notification of Intent to Export. |
| Aug 25, 1978 | 43 | 38057 | Incorporates Hearing Record of Effluent Standard Regulations into Hearing Record for Ban Regulations. |
| Sept 22, 1978 | 43 | 43048 | Notice of Cross-Examination of Versar. |
| Nov 1, 1978 | 43 | 50905-07 | Interim Rules: Applications for Exemption from PCB manufacturing ban. |
| Jan 2, 1979 | 44 | 108-109 | Notice that enforcement is postponed until regulations are promulgated. |
| May 21, 1979 | 44 | | Promulgated Ban Regulations |

Food and Drug Administration

| <u>Date</u> | <u>Vol.</u> | <u>Pages</u> | <u>Subject</u> |
|-------------|-------------|--------------|---|
| 1972 | 37 | 5705-5707 | Notice of Proposed Rule-Making. |
| Jul 6, 1973 | 38 | 18096-103 | Limits of PCBs in Foods, etc., Aug. 8 Corrections. |
| 1975 | 40 | 11563-66 | PCBs in Paper/Food Packaging Material. |
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National Cancer Institute

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VERSAR REPORTS TO EPA RELATED TO PCBs

Contract 68-01-3259 - EPA: Mr. Thomas Kopp, EPA Technical Project OfficerOffice of Toxic Substances

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Contract 68-01-4771

Office of Planning and Management: Mr. Steven Malkenson, Mr. Stephen Weil,
EPA Technical Project Officers

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APPENDIX C
SUMMARY OF MAJOR VERSAR REPORTS REGARDING PCBs

TOXICOLOGICAL STUDIES CONDUCTED UNDER TASK I

Special Report February 19, 1976

(Included in "PCBs in the United States..." as Appendix F)

This study presents the results of two general areas of effort concerned with PCBs: the toxicology of PCBs and the testing of potential substitutes for PCBs.

The toxicological aspects of PCBs are summarized, with emphasis placed on potential human health hazards caused by widespread use of PCBs in the United States. Tests have been conducted on the toxicity and carcinogenicity of PCBs in a variety of animals including rats, dogs, rabbits, and monkeys. In addition, there was an incident in Japan where approximately 1,000 people consumed rice oil that was contaminated with PCBs.

Reviewing the results of these studies led to several important conclusions. PCBs tend to localize in certain tissues and do not break down easily in the body, leading to cumulative or chronic toxicity. Early toxicological evidence concerning the chronic adverse health effects of PCBs from experimental animals such as mice and rats and from observational data in humans has more recently been supplemented by additional experimental findings in monkeys. A close correlation exists for PCBs between the symptoms noted in humans and those noted in monkeys, suggesting that the dose/response relationships and metabolic and excretion phenomena in humans are similar to those in monkeys. According to some pathologists, PCB exposure can cause cancerous liver lesions. Evidence from short-term (several months) exposure and chronic exposure in animals and humans demonstrates that PCBs are a significant health hazard.

Following the review of the toxicological potential of PCBs, a study was made of the procedures necessary for evaluating the potential hazards from possible PCB substitutes. Preliminary information necessary for a thorough investigation of a substance includes:

- 1) Physical and chemical properties
- 2) Manufacturing processes and possible losses
- 3) Chemodynamics, environmental alteration, and bioaccumulation.

PCBS IN THE UNITED STATES:
INDUSTRIAL USE AND ENVIRONMENTAL DISTRIBUTION
FINAL REPORT, TASK I
February 25, 1976

EPA 560/6-76-005

NPLS PB-252-012

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This report summarizes the production, use, and distribution of polychlorinated biphenyls (PCBs) in the United States. The information was obtained by detailed studies of the production of PCBs, the use of PCBs by first tier user industries, the past and present generation and disposition of PCB-containing wastes, environmental transport and cumulative loads, potential alternatives to PCB usage, inadvertent losses to and potential formation of PCBs in the environment, and current regulatory authorities for PCBs control.

It is estimated that approximately 1.5 billion pounds of PCBs have been sold for industrial use in the U. S. since initiation of production around 1930. Of this amount, at least 95 per cent is still in existence; most is in service in capacitors and transformers, but about 290 million pounds are believed to reside in landfills and dumps and about 150 million pounds are believed to be "free" in the environment. The magnitude of these values indicates that there is a strong future threat from PCBs in land disposal sites.

In 1974, U. S. use of PCBs sold by Monsanto, the sole domestic producer, was distributed between capacitor manufacture (22 million pounds) and transformer manufacture (12 million pounds). Imported materials amounted to about one per cent of U. S. industrial purchases of PCBs in 1974; about 400,000 pounds (of decachlorobiphenyl) were used in investment casting, and an estimated 50,000 pounds of new material were used in specialized heat transfer systems.

Although PCB content in industrial wastes can be reduced through various approaches (treatment, substitution, etc.), the large amounts of PCBs already contained in land disposal sites present a severe hazard for the future. Further study of this and other aspects of the PCBs problem, and determination of ways to minimize the hazard, are recommended.

Monsanto and portions of the electrical equipment industry which use PCBs have greatly reduced PCB releases to water and land over the past few years, primarily through improvement of plant housekeeping, improved waste collection and handling, and disposal of liquid wastes through incineration. Waterborne effluents from PCBs production and first-tier use currently release amounts to the environment which are very small in comparison to the amounts entering land

disposal sites from these industries. However, these effluents can have severe local impacts, as evidenced by the current PCB problem in the Hudson River.

There is no plant-scale process used at present for the specific purpose of removing PCBs from industrial wastewater. The best available treatment technology for removal of PCBs from wastewater is carbon adsorption after removal of solids, oil, and grease. Carbon treatment can produce end-of-pipe PCBs concentrations of one ppb or less. Other adsorbents, such as resins, also appear effective to this extent. The most promising method of those water treatment technologies under development for PCBs destruction is ultraviolet-catalyzed ozonation. "Zero discharge" to water of PCBs from production and first-tier use is available only through extensive water reuse plus extensive incineration of lightly contaminated wastewaters.

Incineration is an effective method of disposal for liquid PCBs. Land-filling is the only generally available disposal method for PCBs-contaminated solid wastes, but incineration of these wastes is technically feasible.

Significant amounts of solid PCB (decachlorobiphenyl, or deka) wastes are stored or disposed of on land by the investment casting industry. Air emissions of deka may also be significant in amount, but no evidence of potential health hazards from this material has been reported.

The total present use of PCBs for open and semi-closed applications is not known but is believed to be small in comparison to closed electrical system use. A few capacitor manufacturing plants report recent use of PCBs in vacuum pumps, and a significant amount of carbonless copy paper containing PCBs must still be in inventory and in files.

PCBs are uniquely suited to the requirements of capacitors for A. C. service. Although a number of potential substitutes for this application are under development and test, they are all more flammable than Aroclor 1016 and neither their performance in service nor their potential toxicity to man and other species have been evaluated sufficiently to allow a definitive comparison with 1016.

Alternatives to PCB use in new transformers are available. In addition, testing of promising substitute fluids (termed "self-extinguishing") is under way; these fluids may gain industry-wide acceptance within three years as substitutes for PCB fluids. At present, choice of PCB-filled transformers appears to be based primarily on cost considerations.

No technical barriers to substitution for PCBs (deka) in investment casting waxes are apparent. Several potential alternatives have been previously used by this industry.

Atmospheric fallout is a major source of PCB input to freshwater systems. In Lake Michigan, the PCB contribution at present appears to be much larger than the total PCB inputs from point sources such as municipal sewage treatment and paper recycling.

The importance of atmospheric transport of PCBs relative to other potential inputs to water indicates that the availability of environmental sinks from PCBs is limited, possibly due to short residence times to evaporation in sea water.

Chlorination of waste biphenyl in industrial wastewaters discharged into municipal sewers is a potential mechanism for inadvertent production of PCBs.

At present, regulatory authority over PCBs in the United States is not sufficient to significantly reduce future PCB inputs to the environment, although inputs directly to the waterways from industrial sources can be reduced from their present level. Current disposal practices, except for incineration, tend to delay instead of prevent the PCB entry into the "free" (available to the biota) state, and these practices are regulated only minimally.

DEVELOPMENT OF AN ECONOMIC ANALYSIS METHODOLOGY
FOR EVALUATING REGULATORY ALTERNATIVES FOR PCBs

Task I, Special Report March 9, 1976

(Prepared by Jack Faucett Associates under Subcontract to Versar)
Unpublished

This report presents factors to be taken into account when evaluating alternatives to PCBs to arrive at fair and reasonable time restrictions on the use of PCBs. Also included are a critique of previous estimates of the cost of regulating PCBs, suggestions for improving such estimates, and a survey of the technological aspects of PCB controls.

The following regulatory alternatives are considered:

- 1) Regulation based primarily on chlorine content of Aroclor
- 2) Regulation based primarily on type of use
- 3) Regulation based on responsibility of user
- 4) Regulation of new PCBs
- 5) Regulation of phase-out for PCBs currently in use
- 6) Regulation oriented toward control of waste
- 7) Regulation oriented toward protection of population from exposure to PCBs

After possible regulatory options were identified, a study was made of the information required to evaluate the various alternatives. It was decided that comprehensive information in each of the following areas was needed:

- 1) Present manufacturing and use
- 2) Future substitutions and product changes
- 3) Methods of release to the environment and transport and fate in the environment
- 4) Toxicity, including exposure levels and results of past incidents
- 5) Effect, legality, and options for regulation

Covered under the study of technological aspects of PCB controls are:

- 1) Current and suggested regulations for reducing exposure to PCBs currently in the environment

- 2) Waste disposal control
- 3) Effects of phasing out PCB use
- 4) Limitations on the use of new PCBs in investment casting wax, small capacitors, large power factor capacitors, and electrical transformers

Factors that were analyzed for each of the products above are:

- 1) Risks from continued use
- 2) Present alternatives
- 3) Effect that timing of a ban would have on cost and availability of alternatives
- 4) Benefits from use of alternatives
- 5) Cost of ban of PCBs

This report reaches the following conclusions:

- 1) A total ban on PCBs will have only a minor effect on the current environmental problem but will be necessary in the long run.
- 2) The smooth transition to PCB alternatives is unlikely because of uncertainty about the rationale for and probability of a PCB ban.
- 3) Many of the opinions and cost estimates uncovered in this research indicate that there has been more preparation for debate than for orderly changeover
- 4) Estimates of costs and benefits should be clearly explained to provide incentive for every accurate data supply.

ASSESSMENT OF WASTEWATER MANAGEMENT, TREATMENT TECHNOLOGY,
AND ASSOCIATED COSTS FOR ABATEMENT OF PCBs CONCENTRATIONS
IN INDUSTRIAL EFFLUENTS

FINAL REPORT, TASK II

February 3, 1976

EPA 560/6-76-006

NTIS 251-433/AS

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| Ap. D | Non-carbon adsorption and other research stage PCB treatment technologies | D-1/D-18 |

This report presents the findings of a study of available wastewater management and treatment technology for the purpose of determining toxic pollutant effluent concentrations and daily load achievable in three industrial categories: polychlorinated biphenyls (PCBs) manufacturing; capacitor manufacturing; and transformer manufacturing. All plants in these categories have PCB discharges to either waterways or sewage treatment plants, under normal operating conditions. All plants have discharges to storm sewers or directly to waterways under heavy rainfall conditions.

Extensive survey of wastewater treatment technologies and cooperative laboratory work with several suppliers of treatment equipment and research facilities confirmed that carbon adsorption technology is the best current candidate for successful removal of PCBs from the wastewaters. Uv-ozonation was considered as an alternative. This technology is still in the research stage; however, it offers potential of complete destruction of PCBs all the way to CO₂, water, and HCl.

Another adsorbent technology now in the development stage, AMBERLITE polymeric adsorbents, has demonstrated a PCBs removal efficiency that was roughly equivalent to carbon during laboratory tests. Further testing is needed with this adsorbent to accurately assess its potential.

For scrap oils and burnable solid wastes generated at these plants, high temperature, controlled incineration offers a straightforward method of destruction, whereas scientific landfilling appears to be the best suited mode of disposal for nonburnable contaminated solids.

Zero discharge objectives can be best achieved by eliminating discharge streams and developing recycle systems. All non-contact cooling water would be pretreated. The portion of the pretreated water which would be used in the plant would be treated with carbon, while the excess water would be incinerated in a specially designed system which would allow for energy recovery.

Supporting data, rationale for the selection of above recommended treatment technologies and associated costs are contained in this report.

C-10

DEVELOPMENT OF A STUDY PLAN FOR DEFINITION
OF PCBs USAGE, WASTE, AND POTENTIAL SUBSTITUTION
IN THE INVESTMENT CASTING INDUSTRY

FINAL REPORT, TASK III

JANUARY, 1976

EPA 560/6-76-007

NTIS PB 251-842

This report summarizes the use of decachlorobiphenyl (deka) and polychlorinated terphenyls (PCTs) as wax fillers in the investment casting industry and develops a detailed study plan of the industry. Significant information gathering efforts would be required to establish a complete picture of the practices, processes, and products of this industry, which in this instance, is taken to include casting wax manufacture as well as wax usage in foundries. Definition of the waste streams and emissions from the processes used will require sampling and analysis and gathering available process data from the industry.

An approach to determining the most suitable alternatives to decachlorobiphenyl and PCTs is presented. Filler substitutes and the use of unfilled waxes are the two general alternatives to be studied. At present there appear to be no technical barriers to discontinuation of deka and PCTs as fillers, although use of alternatives may increase product cost on the order of 10 percent. In determining the most promising alternatives, product and process oriented technical factors must be evaluated, but potential environmental and human health effects may prove to be the most important factors in selection. An approach to comparison of alternatives based on technical factors and toxicology data is presented. However, it is anticipated that toxicological data on most alternatives, and also on the currently used materials, will be sparse.

The success of information gathering and in-plant sampling efforts is expected to depend heavily on use of Section 308 (FWPCA) authority. Air emission sampling would be very important to the establishment of an overall process material balance and definition of process losses to the environment.

PCBS INVOLVEMENT IN THE PULP AND PAPER INDUSTRY
FINAL REPORT, TASK IV February 25, 1977 EPA 560/6-77-005
NTIS PB-271 017/6WP

This paper discusses in detail the sources, distribution, and losses of PCBs in the U. S. pulp and paper industry. The major use of PCBs in the industry was as an ink solvent in carbonless copy paper that was manufactured by various paper mills for NCR from 1957 to 1971. Since 1977, PCB levels in recycled paper have diminished rapidly but PCBs are still present in the effluent water from companies that recycle waste paper.

Aroclor 1242, a PCB mixture containing 42% chlorine, was used as a solvent for color reactants which were then microencapsulated and applied to one side of the carbonless copy paper. The microspheres ruptured and released the dye under high pressure, such as would be applied by a pen or pencil. 44,162,000 pounds of Aroclor 1242 were used for this purpose during the period 1957-1971. The average content of PCBs in the paper was 3.4%. A minor use of PCBs in the paper industry, was in inks, which consumed approximately 50,000 pounds of PCBs from 1968 to 1971.

Recycling of wastepaper is a large part of the paper industry. Wastepaper is the third most important source of pulp behind pulpwood and forest product wastes. 19% of the annual output of finished paper is recycled each year. There are 230 paper mills that produce pulp completely derived from wastepaper and 550 other facilities that use 10-15% secondary fiber in their pulp production.

PCB concentrations in paper products, paper mill effluents, and sludges have declined sharply since the use of PCBs in carbonless copy paper was terminated in 1971. Concentrations in paper products are now in the 0-1 ppm range. Sludges have been in the < 1 to 24 ppm range which is common for municipal sewage treatment plants. The major reasons behind this sharp reduction in PCB concentrations are the elimination of PCB use and the disposal each year of 81% of the annual, paper production via incineration or landfilling; together these removed approximately 80% of the PCBs from the paper cycle each year. A small amount of PCBs is added to paper products each year because of the

presence of PCBs in plant influent water, but this contribution does not appear to be significant at present.

Prediction of PCBs in paper mill effluent and products by using a mathematical model of the industry indicates that PCB concentration reached its peak during 1970-71 and is declining to pre-1957 levels because amounts of PCBs in the recycled wastepaper stream are also declining.

On-site measurements and laboratory experiments have shown that PCBs are attracted to the fibers rather than to the water in which they are carried. Discharge of PCBs from a paper mill appears to be by way of suspended solids and removal of these suspended solids should substantially reduce PCB effluents.

The paper industry as a whole is continuing to develop and install water recycling technology in order to minimize waste treatment costs and recover chemicals, heat, and raw materials. New treatment systems also offer the promise of reduced PCB discharges. Some data indicate that PCBs are being removed from influent streams and are becoming fixed in the paper products, thereby producing a net reduction in PCBs which are free in the environment. However, these PCBs could be re-released when the paper products are disposed of.

It is believed that essentially all of the PCBs used in the production of carbonless copy paper have been released to the environment. Half are believed to reside in landfills and the remainder have been dissipated.

A FIRST ORDER MASS BALANCE MODEL FOR SOURCES,
DISTRIBUTION, AND FATE OF PCBs IN THE ENVIRONMENT

FINAL REPORT, TASK V

JULY, 1977

EPA 560/6-77-006

NTIS PB 270-220

The work presented here, an extension of that reported in the Task I report, is an attempt to answer the question, "How did it come about that a compound, such as the PCBs, is so widespread an environmental contaminant?" The work involves the construction of several descriptive mathematical models made necessary by the lack of historical data and the absence of a large base of reliable contemporary measurements. The work is necessary since the measurements that do exist strongly suggest that the PCBs are a persistent menace to the biosphere and hence that actions to control them cannot be delayed while a truly adequate data base is obtained.

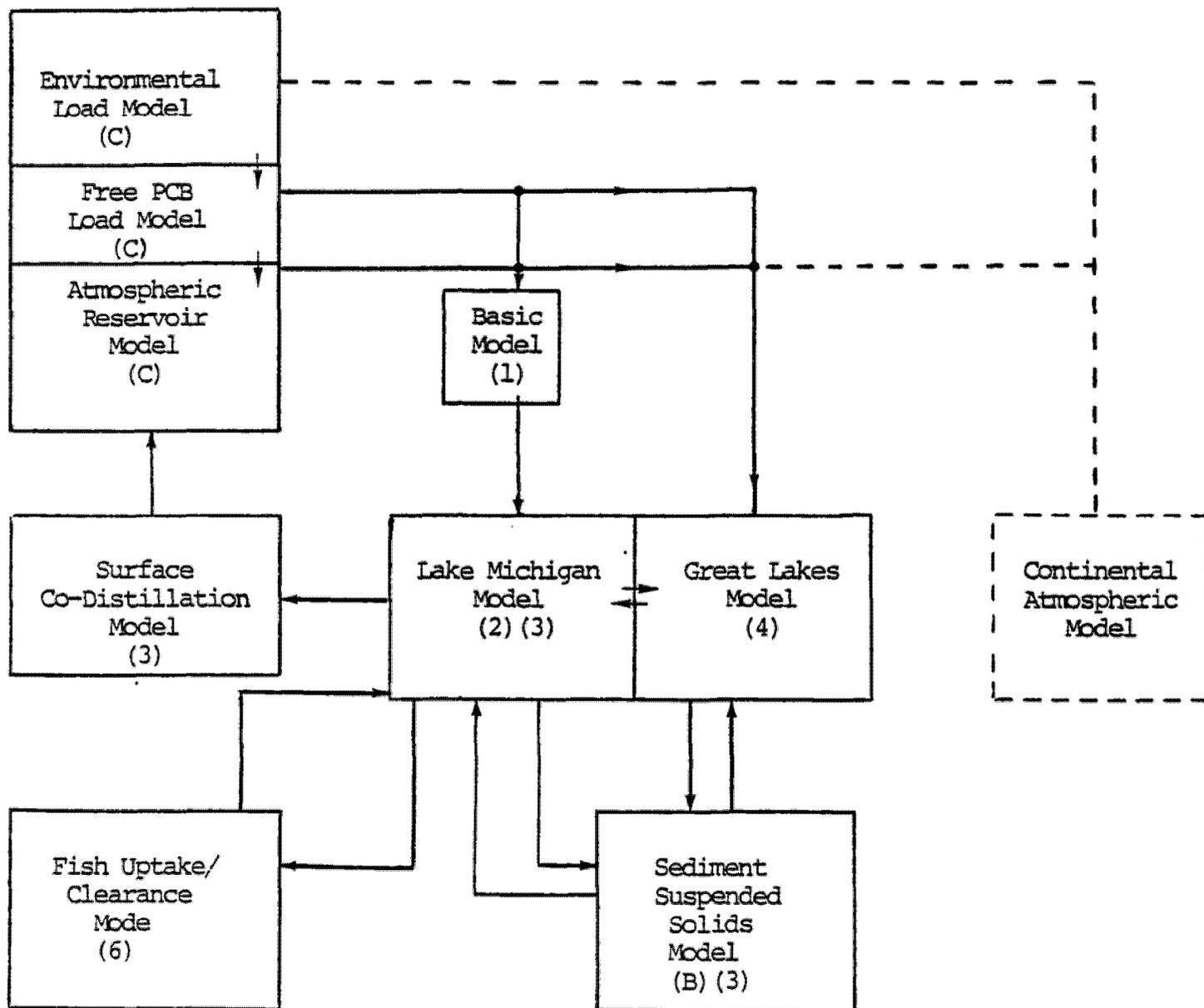
The basic model is constructed on a mass balance principle; that is, all the PCB input to a restricted region of the lithosphere may be accounted for by solution, by uptake on suspended solids, and by uptake within the biota, with the remainder of the input PCBs being carried off by the "loss" processes consisting of surface co-distillation, carryoff by outflowing streams, and entrapment within the sediments.

The model is somewhat complicated by the necessity of an analytic expression for the PCB input rate as a function of time; i.e., the driving function. In the absence of a sufficient amount of data, a model has been constructed to account for the losses to the environment, for the free or "wild" PCB load, and for the atmospheric reservoir of PCBs. The actual relationship of the various parts of the model are shown in Figure I.

Environmental Load Model

Appendix C and Appendix D attempt to determine the magnitude of the total environmental load, the free environmental load, and the atmospheric reservoir of PCBs, all as functions of time.

Figure I
 Schematic Showing Relationship of the Various Sections of Report*



*The number or letter associated with each block refers to section dealing directly with the subject matter.

The results of this analysis are:

- a. In 1975, the total environmental PCB load is estimated to be 3.76×10^8 lbs. within the continental United States.
- b. In 1975, the total free or mobile PCB load in the continental United States is estimated to be 8.31×10^7 lbs. The remainder of the total environmental load is thought to be encapsulated in one form or another (in landfills, for example).
- c. As of 1970, the cumulative atmospheric reservoir contained some 6×10^7 lbs. of PCB indicating a rather rapid exchange between the total mobile PCBs and the atmospheric reservoir.
- d. As of 1975, the PCB concentration in the air near Lake Michigan was of the order of $10 \mu\text{g}/\text{m}^3$.
- e. The estimated half life for fallout from the atmospheric reservoir is 0.9 years.
- f. The average chlorine number for environmental PCBs is of the order of 4.32.

Results of Mass Balance Model Applied to Lake Michigan

The results of this analysis are:

- a. A plausible scenario indicates a present-day PCB concentration (water plus suspended solids) of the order of 7-10 ppt.
- b. Atmospheric fallout constitutes the major input of PCBs to Lake Michigan.
- c. Surface evaporation or co-distillation (the exact nomenclature is not known because the process is incompletely understood) constitutes a significant PCB loss mechanism.
- d. The presence of suspended solids within the water column can be expected to have a dominant effect on the actual (filtered) aqueous concentration.

- e. The sediments should act as a significant sink for the removal of PCBs from the water column.
- f. Even though there is considerable uncertainty as to the proper value for some of the important parameters, the sheer bulk of the water mass makes the aqueous concentration essentially independent of these parameters over wide ranges.
- g. 70 years would be required to reduce the present PCB concentration by one-half in the absence of all external sources.

Results of Mass Balance Model Applied to the Entire Great Lakes System

- a. A plausible scenario leads to an estimate of aqueous PCB concentrations within the range of measured values, i.e., less than 40 ppt.
- b. The estimated average PCB concentration in the sediments of Lake Erie and Lake Ontario fall within an order of magnitude of other estimates.
- c. The estimated fallouts in 1974 onto Lake Erie and Lake Ontario both fall within a few percent of other estimates.
- d. Point source inputs, when introduced into Lake Erie and Lake Ontario, led to PCB concentrations in the aqueous phase as well as within the sediments which are within a factor of 2 or 3 of direct observation.
- e. The lifetime of the present PCB loads in the absence of all sources can be estimated.

Other Results

Other results obtained somewhat incidentally to the main effort include:

- a. An estimate of the bioconcentration rates of PCBs for a trout (about 4×10^6).
- b. An estimate that, for the trout, the uptake of PCBs from contaminated food is 50 times greater than from respiration.

- c. The MacKay and Wolkoff model for co-distillation is apparently not applicable in the situation where infalling PCB complicates the situation.
- d. The significant difference in activity of PCBs in bulk solution compared to that in the surface layer is probably the driving force for the creation of a surface concentration gradient.
- e. A formulation is developed that suggests the possibility of an analysis of the continental PCB atmospheric reservoir.

ASSESSMENT OF THE ENVIRONMENTAL AND ECONOMIC
IMPACTS OF THE BAN ON IMPORTS OF PCBs

FINAL REPORT, TASK VI

JULY 1977

EPA 560/6-77-007

NTIS PB 270-225

This report summarizes an investigation into the uses of imported PCBs in the United States and a determination of the economic impacts which may occur as a result of the impending ban on importing PCBs. Imported PCBs are currently used only for the maintenance of two types of mining machinery produced in the past by Joy Manufacturing Co. PCBs may also be a significant contaminant in polychlorinated terphenyls (PCTs) which wax manufacturers import for use in tooling compounds and investment casting waxes. However, the sole U.S. distributor of PCTs is currently guaranteeing that such contamination is less than 0.05%.

PCE fluids were used as coolants in mining machinery because of their low combustability, low electrical conductivity, and inertness which minimizes system corrosion even at continuous high operating temperatures. The two types of mining machinery manufactured by Joy which use PCBs are loaders, of which there are approximately 350 and which were last produced in 1973, and continuous miners, of which there are approximately 50 and which were last produced in 1970. Converting the motors in the loaders to air cooling would cost about \$6,200 per loader. Converting the continuous miners would require replacement of the cutting heads and would cost about \$65,000 per miner. As a result of the Toxic Substances Control Act, owners of the machinery which use PCB fluids have three options:

- 1) Petition for an exemption to the Act.
- 2) Bear the cost of converting the machinery motors to air-cooling.
- 3) Scrap the machinery.

PCTs are used in wax formulations known as tooling compounds, which are used to provide support to thin walled objects so that they may be

machined without being damaged. After machining, the tooling compound is removed either by melting or by using an aqueous acid solution. The sole producer of tooling compounds which contain PCTs is M. Argueso & Co. of Mamaroneck, N.Y.

Investment casting is a method of producing metal castings which may have complex shapes and which have a surface finish and dimensional tolerance which cannot be matched by other casting processes. It involves first making a pattern out of wax; the pattern is then covered, or "invested," with a refractory coating which hardens at room temperature. The wax is then melted and/or burned out of the mold. The metal is then poured in and allowed to harden. Investment casting is best suited to the production of a large volume of small, intricate parts made of metals which are difficult or impossible to machine.

PCTs are used in investment casting waxes for several reasons. They make the wax harder at all temperatures below the melting point; they cause the wax to harden faster by improving thermal conductivity; and they reduce the coefficient of thermal expansion of the wax, resulting in improved dimensional accuracy in the finished casting. Detailed data on PCT loss to the environment is not available, but possible sources of loss include mold production, mold dewaxing, mold firing and preheating, and wax reclamation. There are eleven manufacturers of investment casting waxes in the United States; three currently use PCTs in their formulations, and three others did in the past but no longer do so. All three current users of PCBs receive them from the same distributor.

The following points with respect to PCT use in tooling compounds and investment casting waxes are noted:

- 1) PCT containing casting waxes cost 15¢ to 25¢ per pound more than non-PCT containing waxes and comprise less than half of the total sales of manufacturers who sell them.
- 2) Of the three manufacturers of PCT containing waxes who ceased using PCTs in their waxes within the past decade, none seems to have been placed in an unfavorable competitive position.

- 3) One investment casting foundry, General Electric, has ceased using PCT waxes. They have apparently found adequate substitutes for use in casting turbine blades, an application which is critically dependent upon high dimensional accuracy and extremely fine surface finish.
- 4) From 2 and 3 above, it appears that acceptable substitutes for PCT-containing waxes are available.
- 5) If imported PCTs are found to contain PCBs in excess of 0.05%, the EPA can take action to ensure adequate quality control.
- 6) If PCTs are found to "present an unreasonable risk of injury to health or the environment," they may be banned.

ASSESSMENT OF THE USE OF SELECTED REPLACEMENT FLUIDS FOR
PCBs IN ELECTRICAL EQUIPMENT

Final Report, Task VII, April 1979

EPA 560/6-77-008

NTIS No. Forthcoming.

This report discusses the use of PCBs as dielectric liquids in transformers, motors, electromagnets, and capacitors. The performance criteria for replacement liquids are summarized and alternative technologies are reviewed.

The major alternatives to the use of PCBs in transformers are:

- Dry type transformers, including gas-filled and cast coil construction
- Oil-filled transformers located in safe locations or installed in a vault
- High fire point liquid dielectric-filled transformers, including silicone, paraffinic hydrocarbon, and synthetic hydrocarbon liquids
- Non-PCB askarel liquids based on chlorinated benzenes

PCB filled electromagnets may be replaced with available oil-filled, high-fire point liquid-filled, or dry type units. Dry air-cooled motors are also available for most of the previous applications using PCB-filled electric motors.

Alternative capacitor liquids are:

Phthalate esters
Alkylated monochlorodiphenyl oxide
Isopropyl biphenyl

Other possible capacitor dielectric liquids are also discussed, and the status of dry film capacitors is reviewed.

PCBs WATER ELIMINATION/REDUCTION TECHNOLOGY AND ASSOCIATED COSTS,
MANUFACTURERS OF ELECTRICAL CAPACITORS AND TRANSFORMERS

ADDENDUM TO FINAL REPORT, TASK II

JULY 2, 1976

EPA 440/9-76-020

The general potential for reduction of water use in the electrical equipment manufacturing industry is favorable, since water has to be carefully excluded from the internals of both transformers and capacitors for the units to meet product and performance specifications. Newer plants in these categories, particularly those of smaller size, use much less water per unit of PCB use than the older plants. However, the existing plants would require a combination of process and plant modifications and wastewater treatment and recycle to achieve a goal of no discharge of PCB-contaminated waters. This addendum to the Task II report summarizes the quantities and sources of the wastewaters; describes the available alternative technologies for reducing or eliminating the discharges on a source-by-source basis; and tabulates the estimated costs for achieving such reduction or elimination.

Section 2.0 of this report addresses the point sources from the capacitor and transformer manufacturing industry with the absolute goal (with a single exception from one plant) of no point-source discharges of any waters. Extensive applications of process changes (from wet to dry unit processes or unit operations), of water segregation practices, of water treatment and recycle practices, and of water-quantity reduction practices were investigated. The residual contaminated wastewaters not eliminated by these practices were then hypothesized to be "incinerated," e.g., heated to a sufficiently high temperature for a sufficiently long time to ensure destruction of PCB contaminants.

Section 3.0 presents the technologies and costs for eliminating PCB contamination of rainwater runoff from manufacturing plants in this industry.

Section 4.0 presents the technical basis and estimated costs for three

alternative approaches to PCBs reduction in the direct discharges from this industry to waterways. The technology and costs presented are based on those of Reference 1 and Sections 2.0 and 3.0 of this Addendum. The approaches were selected to offer a range of PCBs control at various levels of costs.

The estimated costs are as accurate as was possible within the scope of work. Based on previous experience in this area, we feel that the least reliable costs tabulated are those for waste stream segregation. Costs for segregation are highly variable from plant to plant, and accurate estimation is only possible as a result of detailed study of plant layout, piping, etc., which was beyond the scope of this study.

ECONOMIC ANALYSIS OF PROPOSED TOXIC POLLUTANT EFFLUENT
STANDARDS FOR POLYCHLORINATED BIPHENYLS;
TRANSFORMER, CAPACITOR, AND PCB MANUFACTURERS

October 1976

EPA 230/1-76-068

(Prepared by Jack Faucett Associates Under Subcontract from Versar)

This report presents an assessment of economic impacts from PCB effluent controls. Because of the cost of required effluent controls, it is estimated that a minimum of nine and maximum of all eleven direct discharging plants will stop using PCBs depending on the particular regulation issued. According to industry opinion, the estimated minimum is very unlikely because additional PCB controls would encourage stopping use of PCBs. Decisions against investment in control equipment does not mean, however, that the impacts of these regulations are zero. Company decisions to cease PCB use will have impacts, particularly with regards to the timing of the decision to stop using PCBs. The earlier the switch to substitutes the more likely that product prices and performance will change in the transition.

There is evidence that some industries will cease PCB use prior to implementation of Section 307(a) controls. That evidence is based on investment analysis of probable effects on company profits, announced decisions such as those by General Electric and Monsanto, and capacitor/transformer users' preparations for PCB substitutes. These decisions are significant in light of the range of government alternatives that were considered. A major force in government controls affecting PCB use is the Toxic Substances Control Act, which will prohibit the use of PCBs in capacitors and transformers by 1980. The EPA proposed toxic pollutant effluent standards for PCBs in July 1976, and EPA is scheduled to promulgate regulations in January 1977. Depending on the final standard, the affected plants which continue PCB use are likely to install one of the treatment technologies presented below. Circumstances at

each plant could cause deviations in technology costs from the following summaries:

| <u>Government Regulatory Options</u> | <u>Potential Technology</u> | <u>Average Investment Cost/Plant</u> |
|--|-----------------------------------|--|
| A | Process Change & Carbon Treatment | \$ 527,000 |
| B | Maximum Carbon Treatment | \$1,207,000 |
| C | Minimum Carbon Treatment | \$ 392,000 |
| Zero Discharge | Process Change and Recycle | \$ 555,000 |

The cost of each of the technologies varies considerably among plants, but the above costs are an average of investment costs for model plants that were considered.

Since few if any plants will actually install effluent control equipment in response to Section 307 (a) directly, economic impacts can be viewed as emanating from timing of decisions. Monsanto's voluntary ban on PCB production and the new Toxic Substances Control Act will effectively terminate PCB use by 1980 independent of Section 307 (a) provisions.

Total investment costs and total annual costs for each of the four treatment technologies are given in the table below. Our analysis focuses on the 11 direct discharging plants of the 37 plants that manufacture PCB transformers and capacitors.

The following summaries are based on analysis of investment, i.e., investment to meet only federal effluent controls under Section 307 (a), for model plants. Conclusions on whether companies with plants similar to each model would actually install the specified treatment are based on a comparison of present costs of the equipment.

INVESTMENT AND ANNUAL COSTS FOR DIRECT DISCHARGING TRANSFORMER
AND CAPACITOR PLANTS

(Millions of Dollars)

| | <u>A</u> | <u>Required Treatment</u> | | <u>Zero Discharge</u> |
|------------------------------------|----------|---------------------------|----------|-----------------------|
| | | <u>B</u> | <u>C</u> | |
| Number of Plants that would | | | | |
| Install Treatment: | | | | |
| Transformer | 0 | 0 | 0 | 0 |
| Capacitor | 1 | 0 | 2 | 1 |
| Total Investment: ^a | | | | |
| Transformer | 0.0 | 0.0 | 0.0 | 0.0 |
| Capacitor | .26 | 0.0 | .23 | .31 |
| Total Annual Cost: | | | | |
| Transformer | 0.0 | 0.0 | 0.0 | 0.0 |
| Capacitor | .14 | 0.0 | .10 | .19 |

a) Investment analysis indicates an acceptable return on investment.

Alternative A Treatment Costs

EPA standards which would lead firms to invest in Alternative A would cause 5 direct discharge capacitor plants and all 5 direct discharge transformer plants to stop using PCBs in January 1978 rather than by 1980 as would otherwise occur. The one remaining direct discharging capacitor manufacturer could comply with the regulation by installing the necessary treatment equipment. These early curtailments in production would reduce industry-wide production capacity of PCB capacitors by about 35 percent and of PCB transformers by about 50 percent. Industry-wide investment for control equipment would be \$.26 million with annual costs of \$.14 million.

Alternative B Treatment Costs

EPA standards which would lead firms to invest in Alternative B would cause all capacitor and transformer plants among the direct discharges to stop using PCBs in January 1978 rather than by 1980 as would otherwise occur. These early curtailments in production would reduce industry-wide production capacity of PCB capacitors by about 45 percent and of PCB transformers by about 50 percent.

Alternative C Treatment Costs

EPA standards which would lead firms to invest in Alternative C would cause 4 direct discharge capacitor plants and all 5 direct discharge transformer plants to stop using PCBs in January 1978 rather than by 1980 as would otherwise occur. The two remaining direct discharging capacitor manufacturers could comply with the regulation by installing the necessary treatment equipment. These early curtailments in production would reduce industry-wide production capacity of PCB capacitors by about 30 percent and of PCB transformers by about 50 percent. Industry-wide investment for control equipment would be \$.23 million with annual costs of \$.10 million.

Zero Discharge Treatment Costs

EPA standards which would lead firms to invest in zero discharge would cause all but 1 direct discharge capacitor plant and all 5 direct discharge transformer plants to stop using PCBs in January 1978 rather than by 1980 as would otherwise occur. The one remaining direct discharging capacitor manufacturer could comply with the regulation by installing the necessary treatment equipment. These early curtailments in production would reduce industry-wide production capacity of PCB capacitors by about 35 percent and of PCB transformers by about 50 percent. Industry-wide investment for control equipment would be \$.31 million with an annual cost of \$.19 million.

The following economic impacts for the eleven direct discharge plants are based on industry trends as well as data collected from transformer and capacitor users and producers directly.

Average transformer price increases due solely to PCB effluent controls will be minimal because (1) PCBs used by direct discharge plants represent less than 10 and possibly only 5 percent of total transformers and (2) other expected controls and voluntary bans will already have caused a further shift to non-PCB units. The price adjustment for the less effective non-PCB transformers could be significant, but little of this increase can objectively be attributed to Section 307 (a) controls.

The dollar value of all transformer sales is likely to increase more because of higher costs with PCB substitutes than they decrease because of demand response to higher prices. However, recent data indicate that an increase in imports could easily offset any increase from higher prices, leaving domestic producers with slightly lower dollar sales.

Industry-wide capacitor price increases due solely to changes resulting from PCB effluent controls are likely to be less than 5 percent in 1977 and to decrease to less than 2 percent as PCB substitute technology improves by 1980. All environmental controls combined can generate up to a 20 percent increase in average capacitor prices. However, only part of that increase

can be attributed to Section 307 (a) effluent controls which will affect only six specific plants in the entire 19 plant capacitor industry. The remaining plants will be covered by a future regulation, however.

There are no significant effects on energy consumption, balance of payments, or employment. The announced and apparent shifts to non-PCB units and the expected demand for capacitors and transformers are likely to increase rather than decrease sales and industry-wide employment. However, to prevent losses to foreign competition, domestic producers might have to absorb some cost increases in lower profits. Since all of the affected plants are either part of a much larger company or have a reasonably good PCB alternative, reduced profits will not necessarily lead to significant reductions in employment. There will be no reductions if sales in fact do increase and if similar numbers of people are needed to manufacture non-PCB units.

COSTS FOR UV - OZONATION PROCESS

Addendum to Final Report, Task II

September 27, 1976

The costs presented in the Task II Final Report were reevaluated based on new tests that determined that complete removal of the organic content in wastewaters is not required prior to removal of the PCBs.

Comparison of the terminal treatment capital costs of UV-ozonation systems with carbon adsorption systems for reducing the concentration of PCBs in effluent waters to below 1 ppb indicated a greater than 50% higher cost for ozone system over the carbon system. However, combining the pre-treatment costs with the terminal treatment costs results in UV-ozonation system costs about 5 to 10 percent higher than the carbon system costs.

DETAILED COST ESTIMATES FOR ALTERNATIVE PCBs
TREATMENT TECHNOLOGIES APPLIED TO HYPOTHETICAL LARGE AND MEDIUM SIZED PCB
CAPACITOR AND TRANSFORMER MANUFACTURING PLANTS

Addendum to Final Report, Task II

October 15, 1976

The three treatment alternatives for which costs were estimated are:

- A) Process and plant modifications and pretreatment of process water.
- B) Maximum use of carbon adsorption.
- C) Minimum treatment.

The estimates for these three alternatives are:

| | | <u>Large Plant</u> 2,500,000 lbs. PCB <u>use/yr.</u> | <u>Medium Plant</u> 500,000 lbs. PCB <u>use/yr.</u> |
|---------------|--------------------|--|---|
| Alternative A | Capital Investment | \$1,997,900 | \$647,000 |
| | Annual Cost | 528,900 | 164,700 |
| Alternative B | Capital Investment | 3,811,400 | 935,500 |
| | Annual Cost | 922,900 | 222,300 |
| Alternative C | Capital Investment | 1,588,400 | 575,500 |
| | Annual Cost | 374,000 | 138,200 |

COST FOR EQUALIZATION BASIN BASED ON BENTONITE CLAY LINER

Special Report

October 1976

The capital cost for the equalization basin with a bentonite clay lining is shown below. This cost was estimated based on a basin volume of three times the design flow, 24 hour residence time, and \$5.00 per cubic yard of excavation cost consistent with the Task II report basis for the reinforced concrete equalization basin. The report also summarizes total installed costs, maintenance costs, and operating costs, and compares these costs to those estimated for concrete storage basins described in the Task II Final Report.

- Bases:
1. 24 hour retention
 2. 3 times normal flow
 3. Bentonite lining at 80 tons/acre and lining cover @ \$0.3/yd²
 4. 12 ft depth
 5. 10 ft water depth
 6. L/W - 2.0

| | | | | | | | |
|-------------------------------------|------|------|------|------|------|-------|-------|
| Flow (gpm) | 20 | 40 | 80 | 160 | 320 | 640 | 1700 |
| Liquid Vol. (1000 gal) | 86 | 176 | 345 | 690 | 1380 | 2760 | 7340 |
| Width (ft) | 24 | 34 | 48 | 68 | 96 | 136 | 222 |
| Length (ft) | 48 | 68 | 96 | 136 | 192 | 272 | 444 |
| Excavation Cost (\$1000) | 2.6 | 5.1 | 10.2 | 20.5 | 41 | 82 | 218 |
| Lining & Cover Cost (\$1000) | 0.5 | 0.7 | 1.3 | 2.3 | 4.1 | 7.6 | 18.4 |
| Total Basin Cost (\$1000) | 3.1 | 5.8 | 11.5 | 22.8 | 45.1 | 89.6 | 236.4 |
| Pumps & Sump (\$1000) | 20 | 20 | 21 | 22 | 27 | 32 | 42 |
| Total Basin & Pump Cost (\$1000) | 23.1 | 25.8 | 32.5 | 44.8 | 72.1 | 121.6 | 278.4 |

IMPACTS OF SUBSTITUTES FOR PCBs ON FIRE HAZARDS IN COMMERCIAL
AND RESIDENTIAL BUILDINGS

(Draft) Special Report October, 1976

This report reviews the technologies that were being developed for the replacement of PCBs as dielectric liquids in transformers and capacitors. All of the potential substitute liquids are more flammable than PCBs, and this flammability presents a potential fire hazard. The report reviews the changes in design and the effects of changing fire codes and insurance underwriter's requirements on limiting the potential hazard resulting from the use of substitutes for PCBs in electrical equipment.

The report concludes that there is no basis to assume that properly engineered and tested equipment would result in an increase in risk. Any safety problems that occur may be the result of inadequate testing and evaluation prior to commercial introduction of the electrical transformers and capacitors that use the substitute materials.

RECENT ADVANCES IN PCBs DETOXIFICATION IN WASTEWATER
Supplement to Final Report, Task II

January 8, 1977

This report summarizes a brief study made to update information on methods (other than adsorption) for removing or detoxifying PCBs present in industrial wastewater. Information was obtained from Westgate Research and Houston Research on UV-catalyzed ozonation, from Envirogenics Systems Company on catalyzed reduction, and from Environment Canada and others on biodegradation.

In the area of UV-ozonation, both Westgate Research and Houston Research have run tests in which the level of PCBs has been reduced almost to the detection limit of 0.1 ppb. Both companies have stated that they can provide an operational operating costs for a 640 gpm system at \$1,750,000 and \$120,800/yr., respectively. The decomposition products of UV-ozonation of PCBs are not known at this time. The catalyzed reductive dechlorination process being developed by Envirogenics has been tested on PCBs. A 75 ppb concentration of the PCB isomer 4,4'-dichlorobiphenyl was reduced to about 1.0 ppb. The Envirogenics process is currently being used at the Velsical Chemical Corporation plant in Memphis where it was put into service in mid-May. It is expected that a contamination level of 1000-15000 ppm of heptachlor and 500-700 ppm of endrin will be reduced to less than 1 ppb of total contaminants. Envirogenics is expecting a grant to set up a plant-scale system to handle PCBs at one of the GE plants. Decomposition products of this process are being investigated.

The work being conducted on biodegradation by Environment Canada has produced a bacterial strain which subsists solely on PCBs. However, this process is not yet ready for commercial scale demonstration because the lowest PCB concentration reached (as of August, 1976) is 19 ppb.

PCB LEVELS IN NON-CONTACT COOLING
WATERS AND OTHER EFFLUENTS FROM CAPACITOR
AND TRANSFORMER PRODUCTION FACILITIES

Supplement to Final Report, Task II
January 19, 1977

This work provides a tabulation and analysis of the current status of non-contact cooling water waste streams from the capacitor and transformer production facilities which use PCBs.

Data on PCB levels in 1974-75 and 1976 samples from cooling water effluents from PCB capacitor and transformer manufacturers were obtained for ten streams at six different facilities. All but one of the 1976 levels were below 10 ppb total PCBs, and five were at 2 ppb or lower. These levels are compared to combined plant effluents and rainfall runoff samples at four plants. The highest and most variable PCB levels occurred in runoff samples, and the lowest and least variable occurred in the cooling water effluents. In general, one to two ppb appears to be a typical PCBs level for non-contact cooling water in this industry for plants which practice good plant housekeeping and segregate their cooling water.

REFINEMENT OF ALTERNATIVE TECHNOLOGIES AND ESTIMATED
COSTS FOR REDUCTION OF PCBs IN INDUSTRIAL
WASTEWATER FROM THE CAPACITOR AND TRANSFORMER
MANUFACTURING CATEGORIES

Supplement to Final Report, Task II
December 16, 1976

This report augments and refines the available information on technology and estimated costs for abatement of PCB discharges from the capacitor and transformer manufacturers who use PCBs in their products. It includes:

- 1) A description of modifications being performed at two GE plants to reduce PCB effluents;
- 2) An updated cost estimate for UV-ozonation;
- 3) A cost estimate for the use of bentonite-lined equalization basins;
- 4) A general review of the current industry trends towards abatement of PCB discharges.

As of September, 1976, GE had reduced PCB discharges from 8 to 9 pounds per day to one pound per day at their Fort Edward and Hudson Falls manufacturing plants. This was accomplished by:

- 1) Segregating wastewater;
- 2) Preventing spills and leaks from contaminating clean water;
- 3) Decreasing wastewater volume;
- 4) Eliminating batch dumping;
- 5) Treating sanitary wastewater at Fort Edward.

Additional projects intended to reduce PCB discharge to less than 1 gram per day were underway and were scheduled for implementation by April or May, 1977.

These include:

- 1) Recirculating non-contact cooling water;
- 2) Consolidating discharges and impoundment basins;
- 3) Treating impounded water at Fort Edward.

The cost of constructing and operating an equalization basin based on the use of a bentonite clay lining was calculated and compared with figures which had been previously derived for a concrete lined basin. It was determined that the annual operating cost for a bentonite lined basin was approximately half that for a concrete basin the same size. In actual practice, however, the bentonite lined pond would be much larger than a concrete lined basin in order to reduce the frequency of pond dredging and cleaning. Thus, the costs for the two alternatives will be more nearly equal.

Westgate Research Corporation's continuing UV-ozonation development program has produced some system simplifications which made it necessary to re-estimate the cost of removing PCBs in a UV-ozonation treatment plant. The new treatment costs ranged from \$16.00/1000 gal. for a 20 gpm plant to \$1.50/1000 gal. for a 1,700 gpm plant. Typical costs for PCB removal using activated carbon range from \$4.47/1000 gal. for 20 gpm capacity to \$1.18/1000 gal. for 1,700 gpm.

An examination of current industry trends towards abatement and disposal of PCBs revealed several things. Calgon is furnishing GE with carbon adsorption technology and generally agreed with the technical conclusions and cost estimates determined by Versar. There are at least three PCB users which have no discharge of process water or non-contact cooling water to waterways or POTWs. Segregation of cooling water streams appears to be well in hand or underway in five plants. Three potential suppliers of incinerators for waste PCB-containing liquids indicated that they could supply incinerators within 6 to 18 months of receiving an order.

COSTS ASSOCIATED WITH INSTALLING PRODUCTION
EQUIPMENT FOR USE OF NON-PCB DIELECTRIC
FLUIDS IN TRANSFORMER AND CAPACITOR MANUFACTURE

Supplement to Final Report, Task II

January 19, 1977

This report summarizes the costs associated with the expected changeover from polychlorinated biphenyls (PCBs) and PCB-containing askarels to substitute (non-PCB) dielectric fluids in the manufacture of transformers and capacitors.

The approach taken was to contact industry representatives at the various meetings of industry committees dealing with disposal of obsolete PCB-contaminated equipment and waste oils. In addition, discussions were held with other industry personnel from whom information on similar matters had been obtained in the past.

The results indicated that no significant process changes would be required of any producer to convert to a PCB substitute. However, minor to extensive retooling will be required for most capacitor producers that produce their own containers and/or utilize their product capacitors in assemblies (ballast assemblies, for example). Design, testing, and other activities required by the product changes will also result in costs associated with the changeover but not with process changes. In addition, clean-up and disposal costs will be borne by all firms.

MICROECONOMIC IMPACTS OF THE PROPOSED MARKING AND
DISPOSAL REGULATIONS FOR PCBs

FINAL TASK REPORT

April 1977

EPA 560/6-77-013

NTIS PB 267-833/3WP

This study evaluates the economic impact of the draft regulations for the marking and disposal of PCBs. The report includes estimates of the quantities of PCBs and equipment containing PCBs that will be affected, present and future required availability of PCBs, PCB disposal facilities, secondary costs (including storage), recordkeeping, transportation, and the cost of the actual marking. The economic analysis includes estimates of additional costs by year and economic sector, effects on price, investment requirements, and employment. Finally, the effects of compliance on energy requirements and on the availability of strategic materials are estimated.

The basic disposal requirement for all PCBs is controlled use and storage followed by high temperature incineration. The proposed regulations are very specific on what is to be done and how it is to be done. Consideration of the present lack of incineration facilities and the high costs which would be incurred by requiring removal and special handling of fluorescent light ballasts and small capacitors have resulted in the following exemptions from the basic requirements of incineration:

- 1) Until July 1, 1979, non-liquid PCB mixtures, PCB capacitors, and PCB fluorescent light ballasts may be disposed of in chemical waste landfills.
- 2) PCB containers may be decontaminated by triple rinsing.
- 3) PCB transformer may be rinsed and disposed of in chemical waste landfills.
- 4) Small PCB capacitors in electrical equipment do not have to be removed before disposal of the equipment.
- 5) Small capacitors and fluorescent light ballasts used in private homes may be disposed of as municipal solid waste.
- 6) Material or equipment containing less than 500 ppm of PCBs will not require special handling or disposal.

Most storage areas required by the regulations will be established by office and commercial buildings, electrical repair shops, and small industrial buildings for the storage of small capacitors and fluorescent light ballasts removed during normal maintenance. Cost of establishing a small storage area is estimated at \$145 with an annual operating cost of \$95/year. It is suggested that these costs may be reduced by using unused space and establishing the area during a time of slack labor demand. A larger area, such as required by utilities and transformer repair shops is estimated to cost \$1,000-\$5,000 to establish and \$2,125 to operate annually.

The draft regulations require that chemical waste landfills used for the disposal of PCBs be approved by the EPA Administrator for that purpose. At present there are sixteen chemical waste landfills in the U.S., but none have been approved for PCB disposal. Average cost for disposing of materials in these landfills, including freight and state fees, is estimated at \$3.00 per cubic foot of material.

There are currently nine commercial incinerators with the capacity to destroy liquid PCB waste. In addition, three of these facilities have the capacity to destroy PCBs contained in solid wastes. Charges at these facilities are 7-14¢/lb. for liquid waste and \$40/drum for solid waste. Estimated operating cost of a unit capable of shredding and disposing of capacitors is 52¢/lb. It may also be possible to dispose of PCB liquids in cement kilns and power boilers. Shipping charges for liquid PCB wastes in 55 gallon drums range from \$1.14 to \$6.24 per hundred pounds depending upon the number of drums and the shipping distance. In addition, there may be a charge of \$2.85 per platform handling for each drum. There will also be additional recordkeeping charges of \$2 to \$5 per item.

For estimating the total cost to industry which will be incurred in complying with the draft disposal regulations, three options were identified. Option 1 assumes that all PCB capacitors are removed from equipment before it is scrapped. Option 2 assumes that 2/3 of all small appliance capacitors, HID capacitors, and fluorescent light ballast capacitors are not removed from the

equipment but are disposed of as municipal solid waste while the remaining 1/3 are incinerated. Option 3 allows the disposal of fluorescent light ballasts in chemical waste landfills.

Associated with each of these regulatory options are aggregate, industry-wide costs for decontamination, storage, landfill and incineration costs, transportation costs, and recordkeeping costs. The maximum expected cost for decontamination of askarel filled transformers is \$365,000 per year. The cost for storing PCBs prior to disposal is estimated to be \$8.2 million the first year (including cost for setting up storage areas) and \$4.2 million per year in subsequent years. The maximum expected cost for disposal in chemical landfills is expected to be \$5.5 million. The estimated incineration costs range from \$134 million per year for Option 1 to \$39 million per year for Option 3. Estimated transportation costs for incinerating PCBs vary from \$7.4 million to \$13.2 million per year, depending on how many incinerators are assumed with the various disposal options. Recordkeeping costs are estimated to be \$8 million initially plus \$4.0 million per year thereafter.

In addition to the economic impacts which will result from the disposal regulations, there will also be substantial costs incurred due to the marking regulations. Manufacturers will be faced with major retooling costs, on the order of \$25,000 each, in order to comply with the proposed regulations. The majority of the marking cost, however, will be borne by the present users of PCB electrical equipment who need to mark existing equipment. The total cost is estimated to be \$33.2 million.

The aggregate effects which the proposed marking and disposal regulations will have on the electrical pricing, energy consumption, and strategic materials are slight. The price of electricity will increase by an average of 0.06%. The upper bound estimate for increased energy consumption is 17,700 Bbl/day. Reclamation of copper windings from transformers may be inhibited but the total amount affected would be less than 1% of the total copper reclaimed every year in the U.S. and is an insignificant portion of the copper consumed each year.

POTENTIAL IMPACTS OF THE BANS ON PCB MANUFACTURING, PROCESSING, AND USE
Special Report, PCB Activity Analysis Papers

July 11, 1977

This report describes the current uses of PCBs in the United States and draws particular attention to those uses which present environmental hazards or problems of a regulatory or economic nature.

At the present time the only uses of PCBs in the United States are in capacitors, transformers, and the maintenance of a number of mining machines formerly manufactured by Joy Manufacturing, Inc. Capacitor and transformer manufacturers and transformer maintenance shops currently receive their PCBs from Monsanto, the sole U.S. producer of PCBs. Monsanto intends to stop manufacturing PCBs by August 1977, and will cease shipment from inventory as of October 1977, even though the Toxic Substances Control Act permits the manufacture of PCBs for use in a totally enclosed manner through January 1979. Small custom chemical companies may be attracted to this market, requiring definition of allowable manufacturing processes and/or air and water emission regulations. Another possible source of PCB "manufacture" which may arise is the reclamation of used askarels from transformers. This may create some regulatory difficulties.

It appears that either presently or in the near future, GE and Westinghouse will be the only companies who will service PCB transformers. With the sole domestic producer of PCBs about to cease production, GE and Westinghouse will be forced to decide whether to import PCBs before January 1, 1977, in order to meet an anticipated upward trend in PCB use by the transformer service industry. GE has indicated that in no event will they stockpile more than a 1 or 2 year supply.

In any event, the transformer repair industry will remain a potential source of PCB emissions for the immediate future. PCB air emissions from the repair shops may need to be monitored and regulated. The majority of documented PCB releases attributable to the transformer repair industry have occurred

while transporting filled transformers by truck. Draining of transformers before they are shipped would alleviate this problem.

Retrofilling of all PCB transformers with silicone based oil is possible but is not justified on either economic or environmental grounds. The cost would be \$45,000-\$50,000 each for the largest units, and the increased risk of spills makes this environmentally unattractive. Generally, when a transformer is retrofilled, some of the PCBs remain trapped in the windings. However, it may be possible to remove nearly all the remaining PCBs by periodically filtering the new transformer fluid through activated carbon until the PCBs are reduced to an acceptable level.

The users of PCB equipment may be categorized as utility, commercial-industrial, and residential. It appears unlikely that PCBs used in residences (low voltage capacitors) present any great danger because only small amounts of PCBs are present in any residence and there is little chance that one of these capacitors will rupture upon failure. There is a much greater danger from utilities and commercial-industrial users. Spills or losses are known to occur from damaged equipment and through improper handling of PCB liquids. It is estimated that 78,295 pounds of PCBs will be released into the environment each year from utility transformers and capacitors.

It may be possible for PCBs to enter the environment as a contaminant in another chemical or as a by-product of some chemical process. PCB has been reported as a low-level contaminant in some cases where water containing biphenyl is chlorinated. PCBs already free in the environment may become more of a hazard if contaminated sewage sludge is used as a soil conditioner.

Unless carefully worded, regulations to enforce the ban on "distribution in commerce" could have adverse effects on inventories, equipment resale, and maintenance. Strict enforcement could result in the scrapping of large inventories of capacitors without any decrease in the potential for environmental damage. Another question to be considered is that raised by the disposal of PCB wastes in a landfill. That is, when the title to the material passes from the original owner to the landfill operator, does this constitute "distribution in commerce"?

MICROECONOMIC IMPACTS OF THE DRAFT "PCB BAN REGULATIONS"

(Draft Report) March 8, 1978

This report analyzed the economic impacts of an early draft of the proposed PCB ban regulations. The draft report was used by EPA in preparing the final proposed regulations. The material in this report was superseded by the report of the same title published in May, 1978, except that this draft report included two appendices that did not appear in the published version.

Appendix C of the draft report, "Characterization of U.S. Waste Oil Industry," described in detail the uses of waste oil and characterized the structure of the waste oil collecting and re-refining industry.

Appendix D of the draft report, "Supply and Demand Effects of PCB Ban," presented a formal microeconomic analysis of the supply, demand, and price effects of the increased demand expected for substitutes for PCBs. The purpose of this exposition was to correct an error in a similar analysis previously published by Ashford and Murry of MIT⁽¹⁾.

(1) Ashford, Nicholas A., Murry, Albert E. (1976) The Impact of Governmental Restrictions on the Production and Use of Chemicals: A Case Study on Polychlorinated Biphenyls (Report No. CPA-76-3/b). Cambridge, MA: Center for Policy Alternatives, Massachusetts Institute of Technology, April 30, 1976.

"MICROECONOMIC IMPACTS OF THE PROPOSED "PCB BAN REGULATIONS"

MAY 1978

EPA 560/6-77-035

NTIS PB 281 881/3WP

The purpose of this study was to evaluate the economic impacts of the proposed "PCB Ban Regulations." These regulations were prepared by the Office of Toxic Substances of the U.S. Environmental Protection Agency with the technical support of the Interagency PCB Work Group. These regulations implement the bans on various PCB activities which were established by Congress in Section 6(e) of the Toxic Substances Control Act - Public Law 94-469.

The economic costs reported are those directly and indirectly attributable to those changes in future PCB activities which would be caused by implementation of the proposed regulations. From the wording of Section 6(e), it is clear that the intent of Congress was to ban the manufacture of PCBs after December 31, 1978, and to ban the distribution of polychlorinated biphenyls (PCBs) after June 30, 1979. Therefore, the long-term costs of using substitutes for PCBs will be a consequence of this legislated ban on the manufacture of PCBs and not a consequence of discretionary regulatory actions taken by the Environmental Protection Agency.

This analysis of the proposed regulations considered both the direct costs of complying with the requirements and the indirect effects of these requirements on price levels, capital needs, employment, energy consumption, and the availability of strategic materials. The calculated economic impacts were the incremental impacts of the proposed regulations on a base of 1976 practices as modified by the previously promulgated PCB effluent standards and the marking and disposal regulations. The costs of these other PCB regulations were considered during their development and are not considered to be a result of these proposed ban regulations.

The expected transitional and long term costs resulting from the proposed regulations are summarized in the following tables. The report also estimated employment effects and other economic consequences.

Table 1
Transitional Cost Impacts of Proposed PCB Ban Regulation

| <u>Item (Chapter)</u> | <u>\$ Million Per Year</u> | | <u>\$ Million Total</u> | <u>Estimated Reliability of Total</u> |
|------------------------------------|----------------------------|-------------------------|-------------------------|---------------------------------------|
| | <u>1979</u> | <u>Succeeding Years</u> | | |
| PCB Transformers: | | | | |
| Manufacturer clean up costs (16) | \$.1 | 0 | \$.1 | -50% +500% |
| Ban on Rebuilding (4) | | | | |
| Foregone Savings | 14.3 | 3.4% less per year | 420 | +50% |
| Lost Service Time | 2.4 | 3.4% less per year | 75 | +50% |
| Transformer Service (5) | | | | |
| Lost Wages | 1 | 0 | 1 | +100% |
| Spill Prevention Plan | 1 | 0 | 1 | +100% |
| Locomotive Transformers (6) | | | | |
| Retrofill Program | 7 | 0 | 7 | +20% |
| Processing Program | 0 | 2.7 (2 years) | 5.4 | +20% |
| Final Analysis for PCBs | 0 | .1 (1983) | .1 | +20% |
| Reporting | .005 | 0 | .005 | +100% |
| Spill Prevention Plan | .02 | 0 | .02 | +50% |
| PCB Capacitors | | | | |
| Equipment Redesign (15) | * | | | |
| Inventory Obsolescence (3) | 1 | 0 | 1 | +100% |
| Oil Filled Transformers (7) | | | | |
| PCB Analysis and Disposal | 24 | 3.4% less per year | 700 | +30% |
| Mining Machines (8) | | | | |
| Rebuild Loaders | Complete by Dec. 31, 1981 | | 2 | +20% |
| Scrap Continuous Miners | Complete by Dec. 31, 1981 | | .6 | +50% |
| Reporting Costs | .02 | 0 | .02 | +100% |
| Spill Prevention Plans | .04 | 0 | .04 | +50% |

*Data not available to support estimate; probably small cost impact.

Table 1
Transitional Cost Impacts of Proposed PCB Ban Regulation (Continued)

| <u>Item (Chapter)</u> | <u>\$ Million Per Year</u> | | <u>\$ Million Total</u> | <u>Estimated Reliability of Total</u> |
|---|----------------------------|-------------------------|-------------------------|---------------------------------------|
| | <u>1979</u> | <u>Succeeding Years</u> | | |
| Electromagnets (9) | | | | |
| Replacement Cost | \$ 3.5 | 0 | \$ 3.5 | +20% |
| Increased Labor Costs | .5 | 0 | .5 | -100% +900% |
| Hydraulic Systems (10) | | | | |
| Die Casting Machines | | | | |
| Analysis and Sampling | .8 | 0 | .8 | +50% |
| Reporting | .2 | 0 | .2 | +50% |
| Spill Prevention Plans | .5 | 0 | .5 | +40% |
| Decontamination | 7.3 | 7.3 (1980) | 14.6 | -30% +200% |
| Other Hydraulic Systems | | | | |
| Decontamination | 3.6 | 0 | 3.6 | -30% +100% |
| Production Interruptions | ** | 0 | ** | ** |
| Heat Transfer Systems (11) | ** | 0 | ** | ** |
| Compressors (12) | .2 | 0 | .2 | -50% +100% |
| Reclaimed Oil (13) | | | | |
| Increased Cost of Synthetic Road Oil Material | 100 | 100 (years 2-5)**** | 500 | -80% +10% |
| Increased Cost of Road Oil | | 6.4 (years 6-15) | 64**** | -80% +200% |
| Lost Production of Reclaimed Hydraulic Fluid | .4 | .4 (1980) | .8 | +20% |
| Phthalocyanine Pigments (14) | | | | |
| Process Changes | .5 | 0 | .5 | -50% +200% |
| | <u>\$168.3 million</u> | | <u>\$1,802 million</u> | <u>-60% +40%</u> |

**Data not available to support estimate, potentially large cost impact.

***Costs to continue indefinitely until waste industrial oil no longer contains measurable amounts of PCBs.

****Upper bound estimate. Decreased demand may result in significantly reduced impacts.

Table 2

Long Term Cost Impacts of Proposed PCB Ban Regulations

Transformers: (Chapter 16)

| | |
|--|------------------------|
| Increased cost of non-PCB transformers | \$0 to 10 million/year |
| Increased fire losses | Data not available |

Capacitors: (Chapter 15):

| | |
|---|---------------------------------------|
| Increased cost of non-PCB power factor capacitors | \$5.5 to 10.9 million/year |
| Increased cost of non-PCB capacitors | \$7.8 to 10.3 million/year (+ 50%) |
| Increased fire losses | Data not available |
| Decreased service life | Data not available |

Dairylike Yellow Pigment (Chapter 14)

| | |
|---------------------------------------|--------------------------------|
| Increased cost of substitute pigments | <u>\$10 to 25 million/year</u> |
|---------------------------------------|--------------------------------|

| | |
|-------|-------------------------|
| TOTAL | \$23 to 56 million/year |
|-------|-------------------------|

Present value of long term cost impacts assuming 10% discount rate = \$230 to 560 million

PCB MANUFACTURING, PROCESSING, DISTRIBUTION IN COMMERCE, AND
USE BAN REGULATION: ECONOMIC IMPACT ANALYSIS

FINAL REPORT

MARCH 1979

EPA 230-03/79-001

NTIS No. forthcoming

This report is a revision of the report "Microeconomic Impacts of the proposed PCB Ban Regulations." The report summarizes the economic impacts of the promulgated ban regulations and incorporates the information made available during the rulemaking hearings on the proposed regulation. The total economic costs and estimated pounds of PCBs diverted from the environment by the regulation are summarized the following Table.

Economic Costs of the PCB Ban Regulation

| <u>Chapter Number</u> | <u>Item</u> | <u>Total Cost \$ Million</u> | <u>Pounds PCBs Diverted from the Environment</u> | <u>Cost per Pound of PCBs</u> |
|-----------------------|--|--|--|-------------------------------|
| 3 | Scrap Spare PCB Capacitors | 1 | 500 | \$ 2,000 |
| 3 | Remove PCB Capacitors from Equipment in Inventory | 1,000 These costs will be significantly reduced or eliminated if EPA grants exemptions from the "distribution in commerce" ban. | 5,360 | \$187,000 |
| 4 | Ban Rebuilding Askarel Transformers | 397 to 771 (30 yrs) | 47,000 to 925,000 | \$429 to \$16,400 |
| 5 | Retrofill Railroad Transformers to 6% | 6.7 | ** (3.76 million lb) total | ** (>\$1.75) |
| 5 | Retrofill Railroad Transformers from 6% to .1% | 5.15 | ** (80,240 lb. total) | ** (>\$68) |
| 6 | Require Incineration of Transformer Oil | 96 to 510 (30 yrs) | 200,000 | \$480 to \$2,550 |
| 7 | Special Storage Areas at Transformer Service Stops | * | * | * |
| 8 | Retrofill/Ban PCB Miner Motors | 2.6 to 4.3 | ? (27,500 lb total) | ? (>\$94 to \$155) |
| 9 | Ban Rebuilding Electro-magnets | .96 | 200 to 2,000 | \$480 to \$4,800 |

*Information not available in record to make estimate.

**Figure represents total amount of PCBs in this use. Information not available in record to make an estimate of amount diverted from the environment.

ECONOMIC COSTS OF THE PCB BAN REGULATION (Continued)

| <u>Chapter Number</u> | <u>Item</u> | <u>Total Cost \$ Million</u> | <u>Pounds PCBs Diverted from the Environment</u> | <u>Cost per Pound of PCBS</u> |
|-----------------------|--|------------------------------|--|-------------------------------|
| 10 | Decontaminate Hydraulic Systems | 21.4 to 25 | 470 to 2,390 | \$6,000 to \$53,000 |
| 11 | Decontaminate Heat Transfer Systems | 12.8 to 17.2 | 1,872 to 2,496 | \$6,870 |
| 12 | Decontaminate Compressors | .2 | * | * |
| 13 | Ban Use of Waste Oil on Roads | 0 to 31.7/year | 8,073/year | \$0 to \$3,925 |
| 14 | Phthalocyanine Blue Pigments | .425/year | 544/year | \$781 |
| 14 | Diarylide Yellow Pigments | .478/year | 441/year | \$1,084 |
| 15 | Spill Materials (50-500ppm)-to Chemical Waste Landfill | * | * | \$182 |
| 16 | Ban New Large PCB Capacitors | 5.5 to 11/year | 14,200 | \$387 to \$775 |
| 16 | Ban New Small PCB Capacitors | 6.6 to 18.9/year | 6,930/year | \$950 to \$2,730 |
| 17 | Ban New PCB Transformers | 0 to 10/year | 12,000/year | \$0 to \$833 |

*Information not available in the record to make estimate.

| | | | | |
|---|--|-----------------------------------|---|------------------------------|
| BIBLIOGRAPHIC DATA SHEET | | 1. Report No. EPA 560/6-79-004 | 2. | 3. Recipient's Accession No. |
| 4. Title and Subtitle Polychlorinated Biphenyls 1929-1979: Final Report | | | 5. Report Date May 16, 1979 | |
| 7. Author(s) Robert A. Westin | | | 8. Performing Organization Rept. No. 474.5F | |
| 9. Performing Organization Name and Address VERSAR, Inc. 6621 Electronic Drive Springfield, Virginia 22151 | | | 10. Project/Task/Work Unit No. | |
| | | | 11. Contract/Grant No. 68-01-3259 | |
| 12. Sponsoring Organization Name and Address Office of Toxic Substances U. S. Environmental Protection Agency Washington, D. C. 20460 | | | 13. Type of Report & Period Covered Final Report | |
| 15. Supplementary Notes EPA Program Manager: Mr. Thomas E. Kopp | | | 14. | |
| 16. Abstracts The primary emphasis of this report is a summary of the work that Versar performed in support of the EPA's regulatory activities involving polychlorinated biphenyls over the past four years. The report includes summaries of 24 reports on PCBs that Versar submitted to EPA during this period. Also included are a summary of the uses of PCBs from 1929 through 1979, a review of much of the early literature on the uses and toxicity of PCBs, and a discussion of the various regulatory activities that limited human exposure to PCBs and eventually banned their manufacture, processing, and use. | | | | |
| 17. Key Words and Document Analysis. 17a. Descriptors Polychlorinated biphenyls PCBs Regulations Water Pollution Abatement Economic Analysis Toxic Substances Control Act Toxicity Environmental Transport Effluents | | | | |
| 17b. Identifiers/Open-Ended Terms | | | | |
| 17c. COSATI Field/Group | | | | |
| 18. Availability Statement | | | 19. Security Class (This Report) UNCLASSIFIED | 21. No. of Pages 90 |
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United States
Environmental Protection
Agency

Region 10
1200 Sixth Avenue
Seattle WA 98101

December 1980



Pacific Northwest Region Environmental Quality Profile



Preface

This is the fourth annual report to the people of the Pacific Northwest on the status of our environment. The information presented in this report has been compiled by the Environmental Protection Agency (EPA) in cooperation with the States of Alaska, Idaho, Oregon, and Washington. Valuable contributions have also been made by numerous individuals as well as other institutions.

While the Northwest United States is viewed as being relatively environmentally "clean" in comparison with other parts of the Nation, there are many problems to be solved. Most importantly, however, the Northwest is growing--more industry attracts more people--and the results of that growth are not always environmentally beneficial. The people of the Northwest consequently face a challenge: accommodating increased growth while retaining one of our greatest resources, a healthful and beautiful environment.

During May and June 1980, when Mount St. Helens erupted, this report was nearing completion. With the exception of the presentation on Mount St. Helens, environmental data used in the report consist of data collected in 1979 and do not reflect the impact of the volcanic eruption.

Space precludes a complete discussion of the many complex technical and economic issues associated with environmental protection. Therefore, the interested reader is invited to contact the Region 10 Office of EPA in Seattle for other publications and additional information. Also, we encourage suggestions on how future issues of this publication can be made more useful.



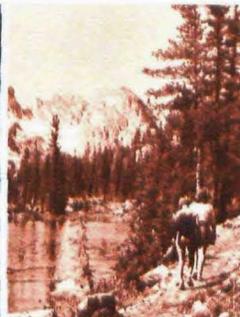
Donald P. Dubois
Regional Administrator, Region 10
U.S. Environmental Protection Agency
Seattle, Washington 98101

December, 1980

Contents/Summary

1 Mount St. Helens

The 1980 series of Mount St. Helens eruptions created troubling uncertainties for environmental and public health officials in the Pacific Northwest. The surge of mud, fallen timber and other debris, plus the heavy fallout of volcanic ash into many areas of the region, raised questions about the quality of drinking water, the ability of sewage treatment plants to withstand the ash flushed into sewer systems, and the possible health effects on people from inhaling potentially dangerous quantities of volcanic dust. Many fears about serious environmental consequences were quickly dispelled, but no immediate answers are available for questions about long-term health effects.



5 Solid Waste and Hazardous Substances

Problems with traditional methods of solid waste disposal and the need to conserve natural resources and energy have prompted the use of new approaches in Region 10 solid waste management.

In particular, communities are recycling more recoverable materials and considering energy recovery from municipal waste.

Production, use, and disposal of hazardous substances is a major concern in Region 10. However, stringent regulatory programs, including new hazardous waste regulations, are being implemented to better manage these materials. EPA requires monitoring of radioactive materials and pesticides, although the states have primary enforcement duties for controlling these substances.

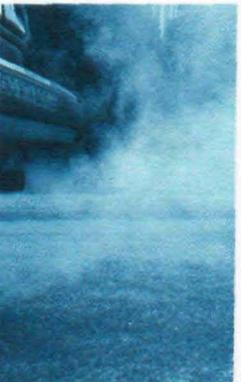


9 Air Quality

In 1979, most areas in Region 10 met air quality standards. Standards for total suspended particulates were exceeded in 16 areas as well as a number of others where fugitive dust is a problem.

Sulfur dioxide standards are being exceeded in three areas of Idaho and one area of Washington.

Carbon monoxide levels in all four states are expected to be controlled by various transportation management strategies. Ozone standards were exceeded in both the Portland and Seattle areas. To attain standards, controls on point sources and area sources either have been implemented or are planned.



18 River Water

Portions of many of the Region's major rivers have marginal water quality with respect to the Federal water quality goals, and the overall 7-year trend has shown little improvement. Much of the existing degradation is due to a variety of non-point sources which should eventually be controlled by area-wide wastewater management programs. Some is contributed by point sources, such as industries, which are controlled through state and Federal pollution permits. Natural occurrences are also responsible for some of the problems. The water quality criteria most often exceeded are those for temperature, bacteria, nutrient levels, turbidity, solids, and heavy metals.

Lakes

33

Many of the Region's major recreational lakes have water quality and other problems which impair their recreational use—principally algae and aquatic weed growths and excessive sedimentation. Primary sources of these problems are stormwater runoff from urban and agricultural lands, sewage and septic discharges from residential areas and recreational facilities, and irrigation return flows. A variety of measures have been taken to restore the water quality in some of the lakes.

Marine Water

40

About one-third of the Region's classified commercial shellfish growing areas are closed during at least part of the year. These closures are primarily due to fecal bacteria contamination caused by inadequate sewage treatment. Others may be due to seasonal runoff from agricultural and forestry activities, and industrial point sources, such as pulp mills. Naturally occurring outbreaks of "red tide" also necessitate the closure of some areas on a seasonal basis.

Drinking Water

44

Drinking water in the Northwest and Alaska is generally considered to be safe, but five waterborne disease outbreaks have occurred within the past year, and others are suspected but unconfirmed. Water system compliance with the bacteriological standards has remained fairly constant from Fiscal Year 78 to Fiscal Year 79; however, improvements have been made in achieving compliance with the bacteriological monitoring requirements. Improvements in compliance with both bacteriological monitoring and standards are expected to occur in Fiscal Year 80.

Noise

46

The Federal Noise Control Act of 1972 gives EPA authority to set standards for cars, trucks, interstate railroads, aircraft, etc. However, the primary responsibility for noise control rests with state and local governments. With technical assistance from EPA as required, each community develops the programs that meet their unique requirements.

Summary of Environmental Indicators

| MEDIA | INDICATOR | OREGON | | WASHINGTON | | IDAHO | | ALASKA | |
|-------------------------------|--|----------------|---------------|----------------|---------------|----------------|-----------------|----------------|-------------------|
| | | CURRENT STATUS | TREND | CURRENT STATUS | TREND | CURRENT STATUS | TREND | CURRENT STATUS | TREND |
| Air Quality | Number of areas exceeding standards | 6 | Little change | 8 | Little change | 5 | Little change | 2 | Little change |
| River Water Quality | Percentage of monitoring stations meeting water quality goals (based on worst 3 months) | 30% | Little change | 50% | Little change | 30% | Slight decrease | 10% | Insufficient data |
| Lake Water Quality | Percentage of major recreational lakes with little or no use impairment | 58% | Little change | 50% | Little change | 57% | Little change | 87% | Little change |
| Marine Water Quality | Percentage of classified shellfish harvesting waters open | 50% | Little change | 68% | Little change | | | 100% | |
| Drinking Water Quality | Percentage of population served by water supplies in compliance with regulations for bacterial contamination | 72% | Improving | 69% | Improving | 64% | Improving | 43% | Improving |
| | Percentage of community water supplies in compliance with regulations for bacterial contamination | 58% | Improving | 17% | Improving | 63% | Improving | 18% | Improving |
| Noise | Percentage of population covered by enforcement of state/local noise regulations | 50% | Improving | 50% | Improving | 5% | Little change | 35% | Improving |
| Solid Waste Disposal | Number of recycling centers in operation | 300+ | Improving | 300+ | Improving | 20 | Improving | 2 | Improving |
| | Number of hazardous waste handling facilities in operation | 3 | Improving | 4 | Improving | 2 | Little change | 0 | |

Mount St. Helens



The eruption of Mount St. Helens occurred last spring just as this report neared completion. Consequently, the fallout from the volcano suddenly threw into question many of EPA's conclusions regarding the condition of the environment in the Pacific Northwest.

Data EPA had collected on levels of turbidity and solids in the surface waters of southwestern Washington were made obsolete by the movement of tons of mud, fallen timber, and other debris into rivers and lakes in the immediate vicinity of Mount St. Helens (see Figure 1). Over a wider area, the turbidity created in dozens of drinking water supplies in Washington, Idaho, and Oregon cast doubt on EPA's assessments of the drinking water quality in those systems most affected by mudflows and ash fallout. For a few days, it was uncertain whether the turbidity would interfere with the disinfection needed to assure safe drinking water.

Emissions of ash and various gases produced what will undoubtedly be long-standing problems related to attainment of national ambient air quality standards for particulate matter throughout the Region. In addition, serious questions were raised about the volcano's contributing significantly to acid rain formation well beyond the borders of the Pacific Northwest.

The potential for far-reaching effects became apparent by early July when an English scientist claimed that ash from Mount St.

Helens was responsible for the unseasonably cold summer temperatures in Great Britain and for the rains that drenched the Wimbledon tennis tournament.

The concerns of the English scientist seem frivolous when compared with those of people living in Washington, Idaho, and Oregon in the aftermath of Mount St. Helens' May, June, and July eruptions. For people who had to dig their way out of mudflows or heavy ash fallout, it was a matter of personal health, and some very important questions arose. Was it safe to handle the ash? Was their water fit to drink? Was the air safe to breathe?

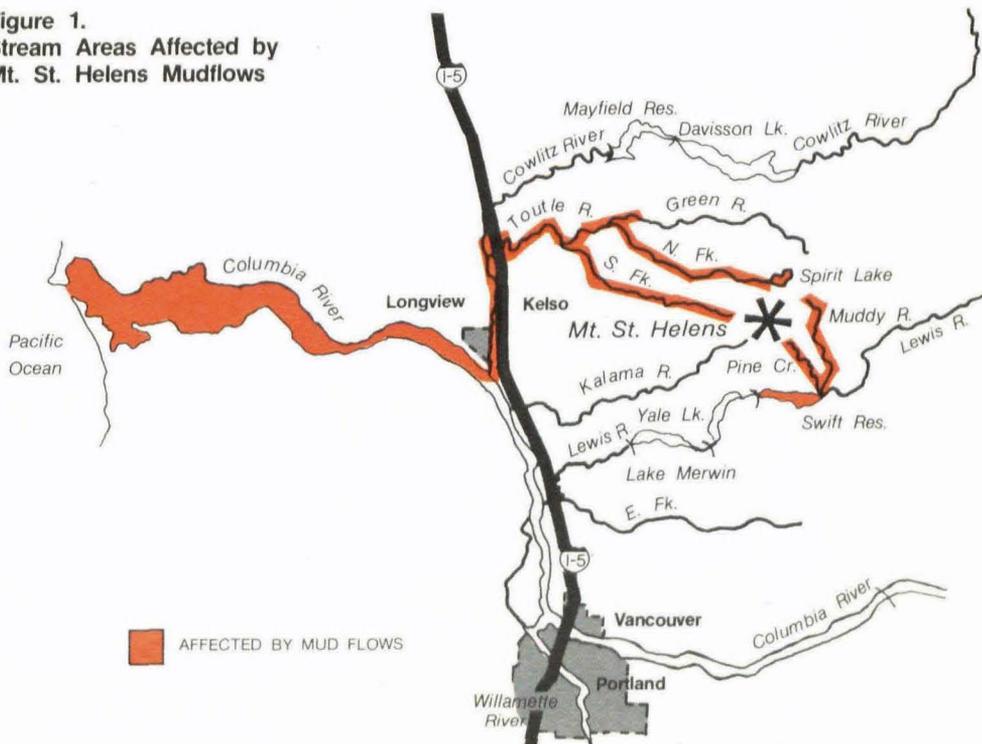
These were the three chief questions facing EPA and state environmental and health agencies in the wake of the volcano's eruptions—in particular the one of May 18. Within hours of this explosion that blasted more than 1,000 feet off the top of the mountain, EPA sent a specially equipped aircraft over areas of central Washington downwind from the volcano to measure radioactivity. No radioactivity above normal background levels was discovered in the

aerial measurements, which was confirmed through analyses of ground ash samples taken the same day.

It was also promptly determined that the ash was highly conductive. Upon contact with moisture, deposits of ash on transformers and other electrical equipment could cause power outages. Utility operators took the precaution of using emergency crews to blow ash from substation transformers before rainfall could produce interruptions in electrical service.

Rumors that ground-level ash fallout was highly acidic were rapidly dispelled. U-2 flights discovered high acid content of particles in the atmosphere, but fears that the ash might etch painted surfaces of cars or, worse yet, produce acids under face masks being used for protection, were alleviated when tests of ground ash showed almost no acidity. Also, there were no toxic properties in the ash. This was established by EPA personnel who, in the scramble to obtain all available information about ash characteristics, acted as a clearinghouse for analyses quickly performed by state, Federal,

Figure 1.
Stream Areas Affected by Mt. St. Helens Mudflows



and private laboratories throughout the Northwest. The ash did consist of minute fractions of cobalt and other inert heavy metals, but in quantities so small that by May 21 EPA was able to determine that they presented no danger to people inhaling airborne ash or drinking water containing ash particles.

Of greater concern was the threat to drinking water posed by the high levels of turbidity in surface streams and reservoirs receiving heavy deposits of ash or mud (see Figure 2). (In the first few days after the May 18 eruption, some drinking water supplies in southwestern Washington had so much mud they were facetiously described as "too wet to plow and too thick to run.") Fortunately, in those cases where mud clogged drinking water intakes, system operators were able to draw water from alternate sources; operators at other systems with high turbidity levels adjusted the amount of chemicals used in flocculation and, by keeping a close watch on filtration equipment, managed to provide water that was safe to drink.

Many systems came dangerously close to running out of water because of the heavy use of domestic supplies to flush away the accumulations of ash that paralyzed their communities. Several systems rationed water usage, but no community anywhere in the Northwest ever completely ran out.

The accumulations of ash that were sluiced into storm drains and sanitary sewers created problems for the operators of municipal sewage treatment plants. At one point in Spokane, a city hit hard by the May 18 fallout, it was reported that no less than 30 percent of the influent entering the city's sewer system consisted of solids. Mechanical equipment was threatened by the load, making it necessary to temporarily bypass treatment facilities. Spokane, like other cities, reduced treatment levels from secondary to primary to avoid expensive damage to their equipment. Managers of local sewerage authorities correctly preferred to tolerate increased discharges of oxygen-demanding materials from their outfall lines for a few days rather than risk permanent damage to their systems that might leave downstream waterways without any treatment at all for what could have been months to come.

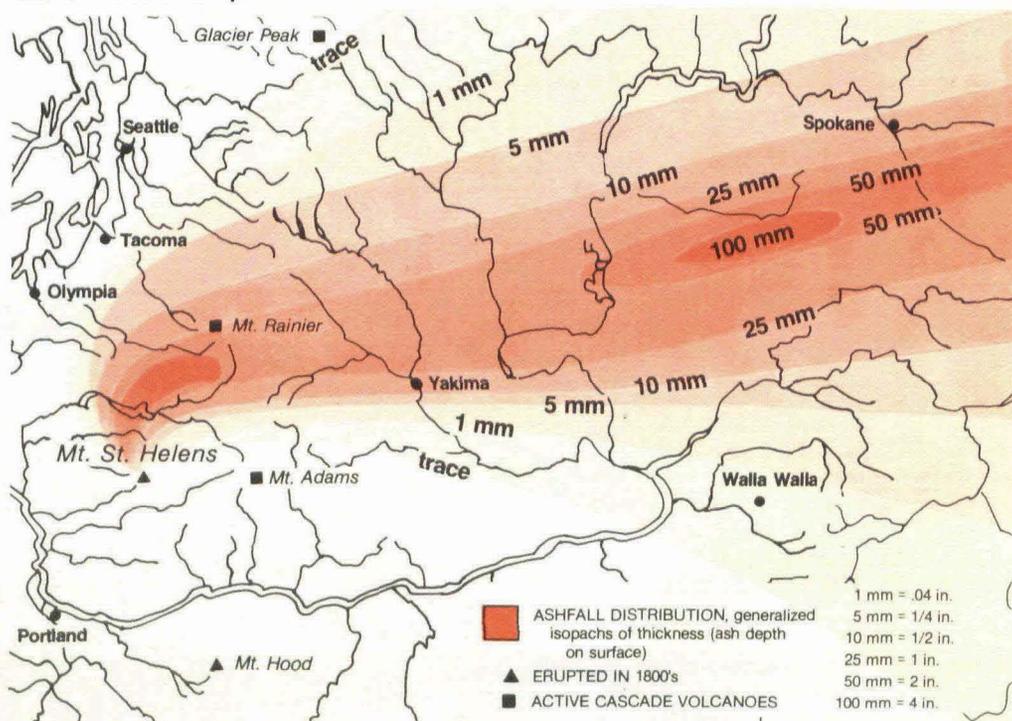
Water quality standards were undoubtedly violated in a few areas of the Pacific Northwest, but EPA and state and local health officials were more worried about the effects of violations of national ambient air quality standards for total suspended particulates (TSP).

Local air pollution control agencies throughout the Pacific Northwest recorded TSP levels far in excess of the standard set to protect human health. Figure 2 shows the dispersion pattern from the May 18 eruption and Figure 3 shows the highest 24-hour concentrations of particulates observed after the Mount St. Helens eruptions of last May and June. Monitors in Yakima, for example, recorded levels of particulates reaching 30,000 micrograms per cubic meter of air. Historically, the Pacific Northwest has rarely experienced air pollution episodes in which TSP levels even remotely approached the 1000-microgram level, and Figure 3 shows the normal average 24-hour levels of TSP during 1979.

The standard set by EPA to protect human health is 260 micrograms per cubic meter of air over a 24-hour period. When that standard is exceeded and weather forecasts indicate conditions are likely to get worse, air pollution control agencies begin to consider preventive actions to protect public health. If TSP levels reach 375 micrograms for a 24-hour period, air pollution control agencies issue alerts to advise susceptible people about dangers to their health. At 625 micrograms of TSP, warnings are issued that advise stronger precautions. At 900 micrograms, the "emergency" stage is reached and local governments are empowered to impose restrictions on personal and commercial activities that would send TSP concentrations above 1000 micrograms, at which level there is significant harm to human health.

At this writing, it is still too early to tell just how long people living in heavy fallout areas can expect exposure to TSP concentrations dramatically above levels that prevailed before the eruption. Even though local efforts to

Figure 2.
Ash Deposits Following
Mt. St. Helens Eruption



remove ground ash in many communities bordered on the heroic, enough ash remained for several weeks after the initial cleanup to send TSP concentrations soaring above 1000 micrograms. As one example, Spokane—despite a successful cleanup of the ash from the May 18 fallout—experienced winds on June 1 (a full 2 weeks later) that caused monitoring equipment to record TSP in concentrations of more than 2300 micrograms during one 8-hour period.

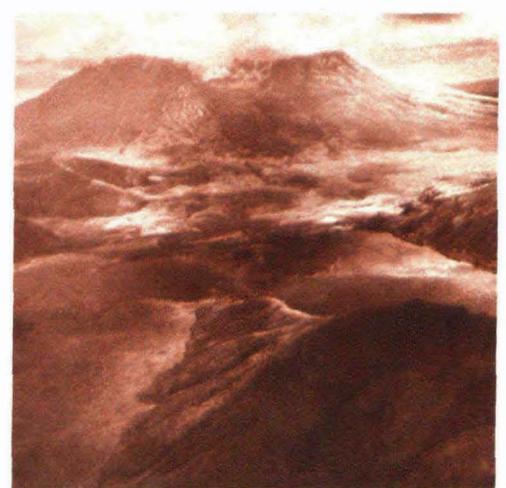
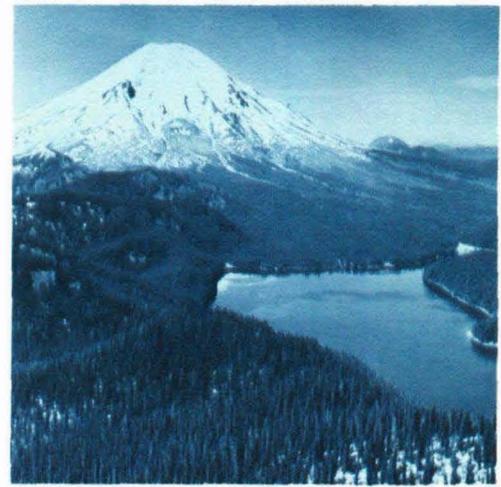
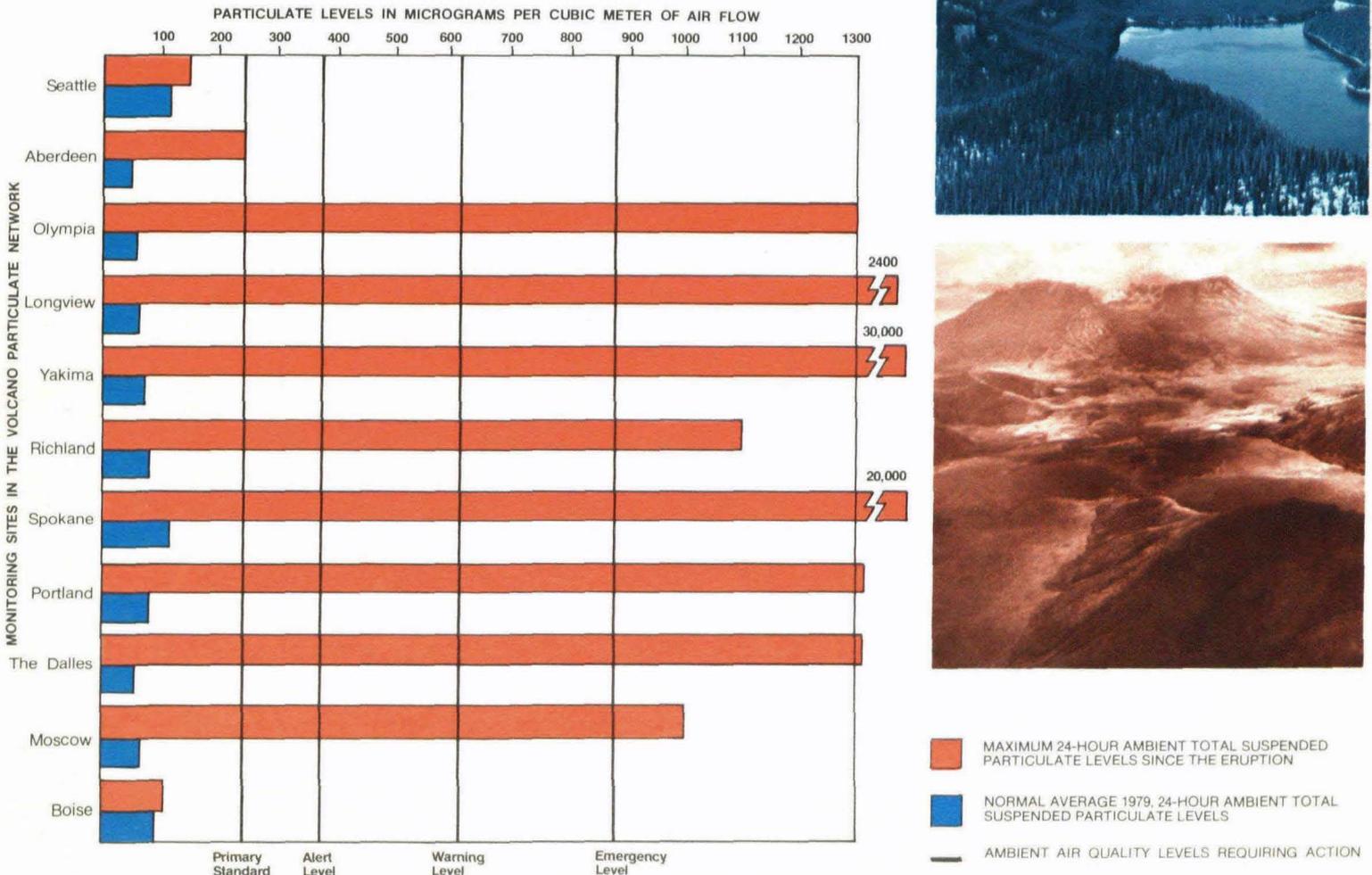
So much volcanic dust lay on the ground in many fallout areas that it was subject to redistribution every time a stiff wind came up.

This worried public health officials who were trying to accurately assess the risk to public health. Their job was made difficult by their inability to predict how long people could expect to encounter heavy, prolonged exposure to ash already on the ground. In addition, they had no way to measure exposure from the volcano's unpredictable future eruptions.

Early reports from the Center for Disease Control (CDC), based on information collected by epidemiologists about hospital emergency room visits and hospital admissions in fallout areas, were not

conclusive about the seriousness of short-term health effects. While the preliminary results of CDC's investigations suggested significant increases in hospital admissions for a variety of respiratory ailments, CDC had not—as this article was being prepared—performed the follow-up studies that would precisely determine the short- or long-term risks to human health.

Figure 3.
Total Suspended Particulate Levels
Since the Eruption



Of special concern to CDC was the potential for people in fallout areas to develop silicosis, an emphysema-like illness produced by heavy exposure to crystalline silica, a known component of volcanic ash. Occupational standards designed to protect workers from crystalline silica exist for the workplace, but none have been devised for ambient air. Direct correlations have been established between the development of silicosis and the exposure of workers engaged for several years in hazardous occupations, but no such correlation exists for exposure of the general population. CDC, in trying to establish that relationship (if, in fact, any such relationship exists) was relying on ambient monitoring data furnished by sampling stations operated by state environmental agencies and local air pollution authorities in cooperation with EPA.

The state and local agencies had long maintained monitoring stations to collect information about total suspended particulates and other air pollutants. With the eruptions of Mount St. Helens, added monitoring capability was needed to measure ambient levels of TSP. State and local agencies promptly responded to the challenge. New sampling sites were set up, new equipment was deployed, and the frequency of monitoring was increased in Washington, Oregon, and Idaho. The monitoring stations used to collect the TSP data are shown in Figure 4.

At as many sites as possible, equipment was installed that enabled state and local agencies to make two kinds of measurements. Not only would "Hi Vol" samplers be used to measure TSP, but other equipment ["Dichot" (Dichotomous) and "IP" (Inhalable Particulates)] was added to measure that fraction of total particulates so small as to be inhalable. Relatively coarse particulates (i.e., larger than 15 microns) cannot be inhaled; they usually are trapped in the nose or throat and can easily be expelled. Particles smaller than 15 microns, on the other hand, can be inhaled. And those smaller than 2-1/2 microns are considered respirable, so tiny they can be drawn deep into the lungs. Respirable particles tend to remain lodged in the lungs for long periods of time and possibly can alter the body's physiological defense systems.

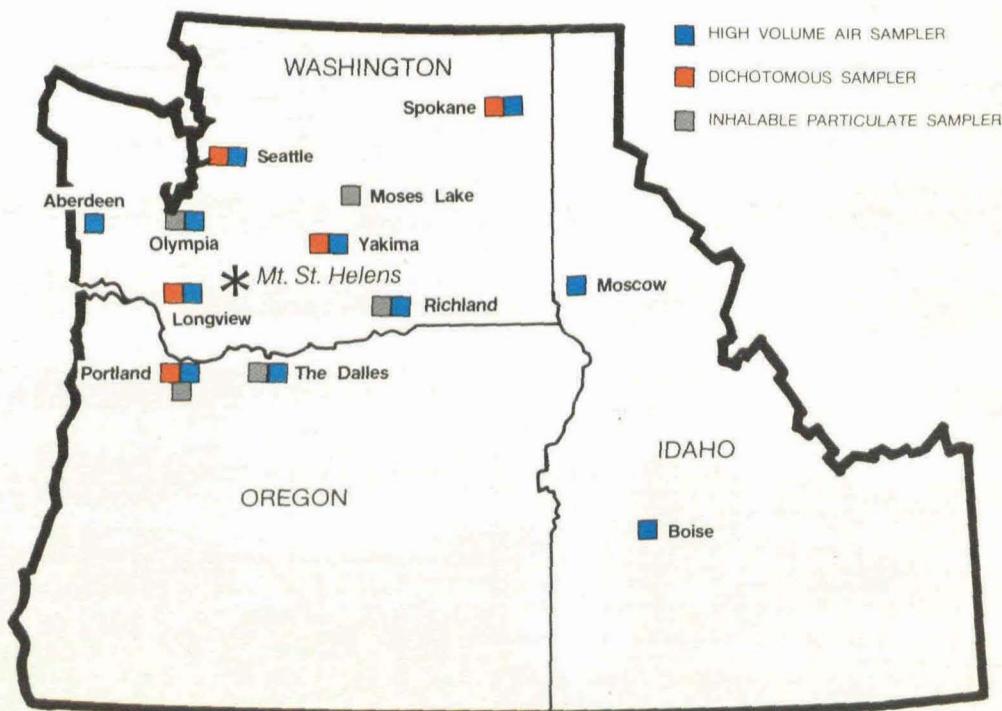
Data from the monitoring network is immediately relayed, as soon as available, to epidemiologists at CDC. This monitoring data will be used by CDC to make correlations between ambient exposures and data collected by CDC's own in-depth investigations of persons exposed to potentially dangerous levels of volcanic ash.

Other monitoring data being collected will help gauge whether emissions from Mount St. Helens will contribute significantly to the formation of acid rain, which is a product of sulfur and nitrogen oxides reacting with water vapor in the upper atmosphere to cause drops of sulfuric acid and nitric acid to return to earth. Although it is well-established that sulfur oxides can be carried by prevailing winds for hundreds of miles, not much is known about the exact process by which acid

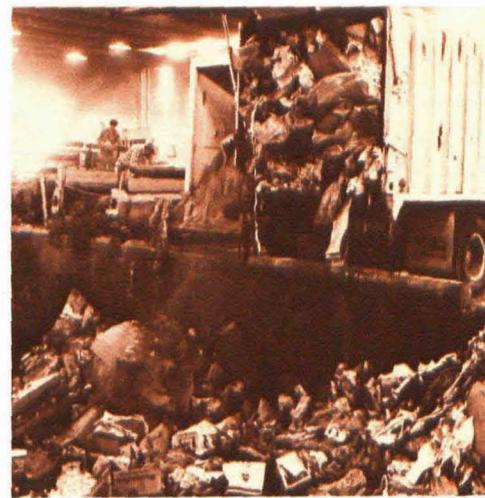
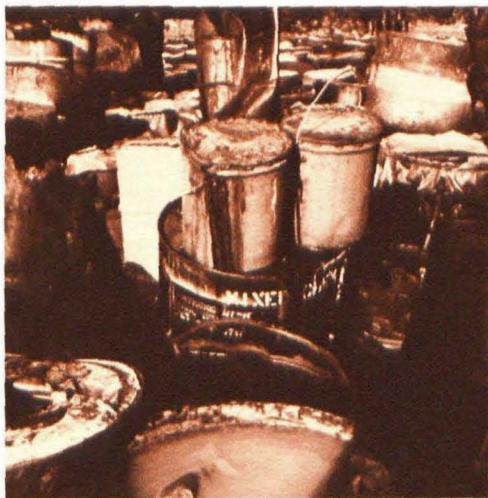
rain is formed or precisely how it is transported in the atmosphere. Mount St. Helens' emission of hundreds to thousands of tons of sulfur dioxide per day was cause for concern by EPA researchers who had already been trying to determine the environmental effects of acid rain.

While there are still many unanswered questions about the long-term effects of the Mount St. Helens eruptions on people and the environment, one fact has clearly been affirmed: man and his environment can all too easily become the victims of changes that upset the fragile balance of our global ecology. Mankind is vulnerable to innumerable environmental stresses, some of which are the result of natural, uncontrollable events.

Figure 4.
Region 10 Volcano Particulate Network



Solid Waste and Hazardous Substances



In general, Region 10 has escaped the environmental problems found in other parts of the U.S. No major scale problems from improper disposal of hazardous substances have been discovered as yet. The problems that have surfaced are being dealt with and remedies are being developed. Open burning of wastes has been virtually eliminated from Region 10, but many environmental problems related to improper disposal of municipal waste remain, with water pollution being a major concern. Scarcity of land for solid waste disposal, concern about limited resources, and serious health hazards arising from improper disposal of hazardous wastes prompted Congress to pass the Resource Conservation and Recovery Act (RCRA) in 1976. In addition, other forms of hazardous substances are regulated by EPA under authorities of TSCA (Toxic Substances Control Act) and FIFRA (Federal Insecticide, Fungicide, and Rodenticide Act). In this increasingly complex area, Region 10 feels they are moving in a positive direction toward protecting human health. The following section summarizes the solid waste and hazardous substances problems addressed in the Pacific Northwest, as well as hazards dealt with by other means.

Solid Waste Disposal

The Resource Conservation and Recovery Act requires that Federal criteria be established for evaluating land disposal operations nationwide. In the past, municipal landfills could often be described as open dumps. These criteria have now been developed and the states in Region 10 have started an inventory to classify disposal sites. Those sites failing the criteria will be designated as open dumps and placed on a state-established compliance schedule for upgrading or closure.

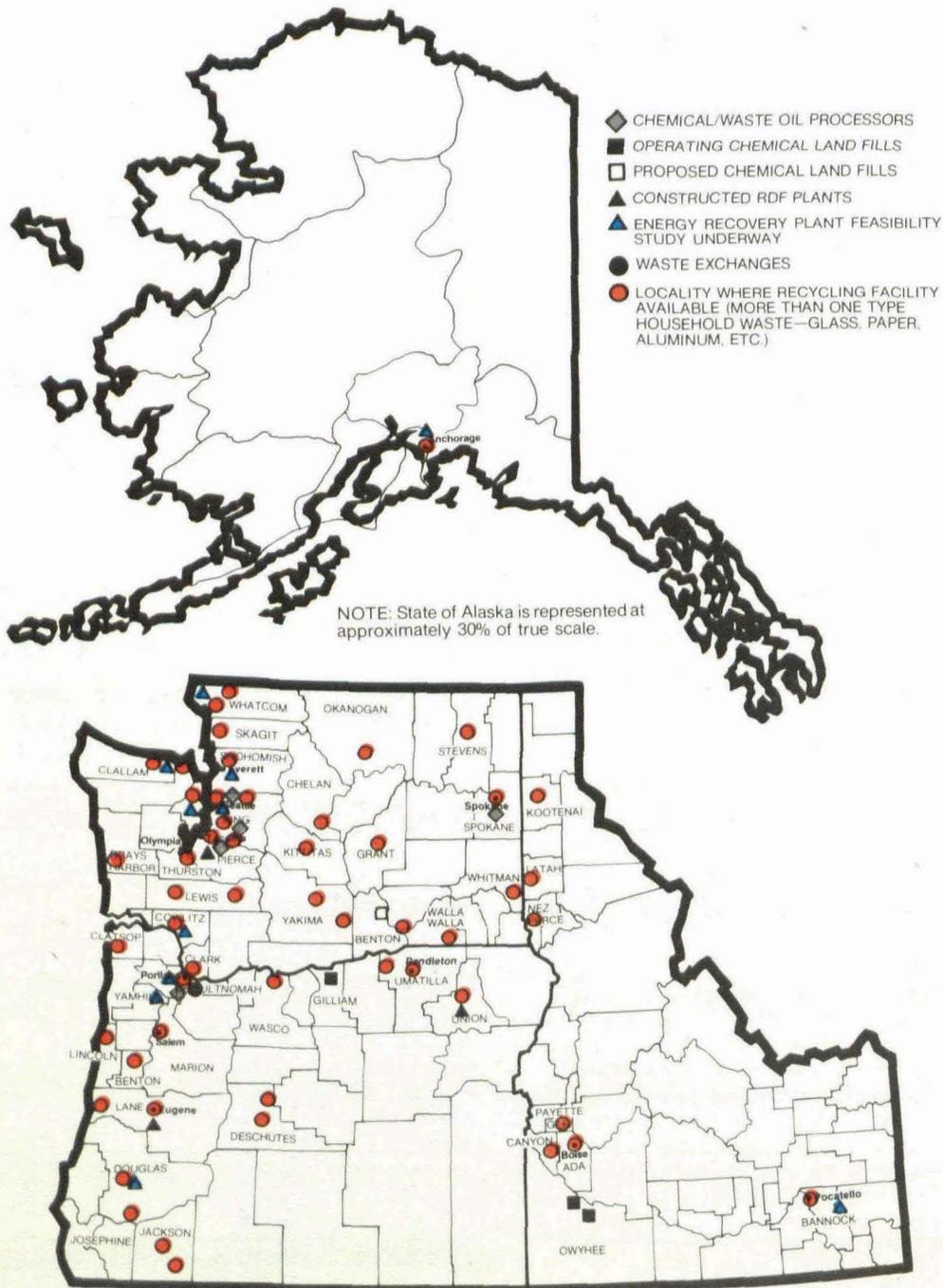
Rainwater draining over the surface of a fill, and filtering into the ground through the wastes, can dissolve (leach) such undesirable substances as chemicals and bacteria into streams and groundwater. Because of the higher rainfall and greater population west of the Cascade Mountains, leachate problems there have been more numerous and serious than in more arid parts of Region 10. Landfills such as those constructed in Lane County, Oregon and Snohomish County, Washington have been engineered for leachate collection and treatment. Older landfills which had serious leachate problems, such as the Cedar Hills landfill in King County, Washington, have installed collection systems that pump leachate into the sewage treatment system. Other landfills may have to close altogether if they cannot be effectively upgraded.

There are other problems related to waste disposal. For example, when garbage decomposes, methane gas is produced as a by-product. Methane is toxic to vegetation and is explosive in certain concentrations. Decomposition can also produce odors. Household wastes, in particular, may attract disease-carrying rodents and insects. Proper disposal with daily cover and proper compaction will reduce many of these problems. Sewage sludge disposal is an increasing problem as water pollution regulations become more strict and landfill space becomes scarce. Alternatives, such as incineration and the use of sludge on farm and forest lands, are being tried. In addition, certain areas have special disposal problems, such as in Alaska where severe cold makes disposal difficult.

Resource Recovery

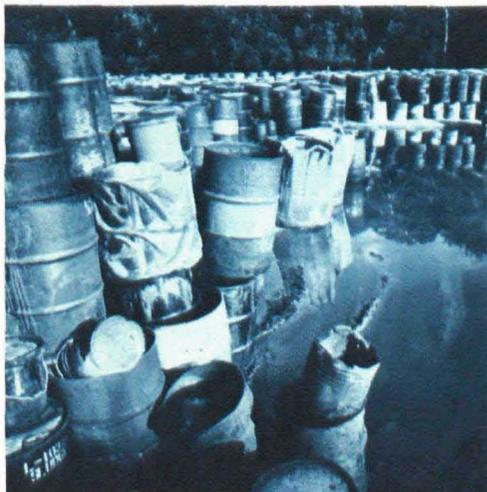
RCRA provides financial assistance to state solid waste management authorities to develop and implement comprehensive solid waste plans, including environmentally sound disposal methods and recovery and conservation programs. In addition, the President's Urban Grant program has provided funding to Seattle and Portland for development of recycling and energy recovery systems. Some municipal wastes, such as glass, metal, and newspaper, can be recycled, and much of the rest can be converted to "refuse-derived fuel" (RDF) or burned to

Figure 5.
Location of Hazardous Waste and
Resource Recovery Facilities in Region 10



create steam or electricity. Lane County, Oregon and Tacoma, Washington are testing RDF plants. Portland and Roseburg, Oregon and Cowlitz County, Snohomish County, and King County, Washington and Boise, Idaho are also studying the feasibility of converting waste to energy (Figure 5). The economics of recycled materials are typically very good in the Portland and Puget Sound areas, but recycling programs in Idaho and Alaska suffer from higher transportation costs and smaller volumes.

Other wastes with a potential for recovery include tires, lubricating oil, and wood waste, which simultaneously present serious disposal problems. Discarded tires gradually work to the surface in a landfill, where they trap water, become a breeding place for mosquitoes, and pose a fire hazard. Recently, however, shredded tires were used as a fuel in boilers at the Georgia-Pacific plywood mill in Toledo, Oregon. Waste lubricating oil is used on roads as a dust suppressant, but can contaminate air and water, plus lead in the oil makes indiscriminate burning or disposal undesirable. Oregon has passed a Used Oil Collection Act that provides for designated collection centers, which will encourage re-refining of waste oil. Wood waste, which can pollute water resources and consume significant space in landfills, is presently being used to produce steam in several Northwest timber mills and utilities, and may also be used in combination with refuse-derived fuel.



Hazardous Substances

The Resource Conservation and Recovery Act mandates government control of hazardous waste from its generation to ultimate disposal, including a manifest tracking system for transporting and a permit system for treatment, storage, and disposal facilities. In May of 1980 regulations were promulgated which will implement the Act. Compared to other parts of the country, there are fewer industrial sources of hazardous waste in Region 10. Most of it is created by manufacturers of chemicals, pesticides, and metals, petroleum refineries, and electroplating operations. These sources are concentrated around Puget Sound and in the Willamette Valley.

For RCRA to be effective, acceptable hazardous waste disposal sites must be made available. Presently, there are two state-licensed chemical landfills in Region 10—one at Arlington, Oregon, and the other at Grand View, Idaho, and a third has been proposed on the U.S. Department of Energy's Hanford Reservation in Washington. The availability of such landfills, coupled with the active involvement of Region 10 states in hazardous waste management, has helped prevent serious incidents involving hazardous wastes in the Region. Nevertheless, there has been opposition to using these landfills to dispose of wastes from out-of-state. In addition, RCRA does not address the problem of abandoned facilities which have posed serious health hazards elsewhere in the country. A national

trust fund for cleanup of abandoned sites has been proposed, and an inventory of such sites is being conducted.

Besides landfills, several other approaches to hazardous waste management in the Northwest have been taken. Waste exchanges in Portland and Seattle assist parties throughout the Northwest wishing to dispose of a hazardous by-product in locating a second party that can use or recycle the material, thereby eliminating a need for disposal. The second party may be a chemical processor that uses the waste as feedstock for another product. Regulations determine how some substances are used; for instance, labeling and disposal procedures have been established for the more than 800 facilities in Region 10 using or storing polychlorinated biphenyl (PCB), a toxic substance used in electrical transformers and capacitors. Some efforts have also been made to rectify past uses of hazardous substances. Each state in Region 10 will participate in a voluntary national program to reduce the exposure of school children to asbestos fiber found in some school buildings. In addition to long-term management plans, emergency response plans have been developed. Units within several fire departments, including Seattle and Tukwila, Washington, have been trained to deal with incidents involving hazardous materials.

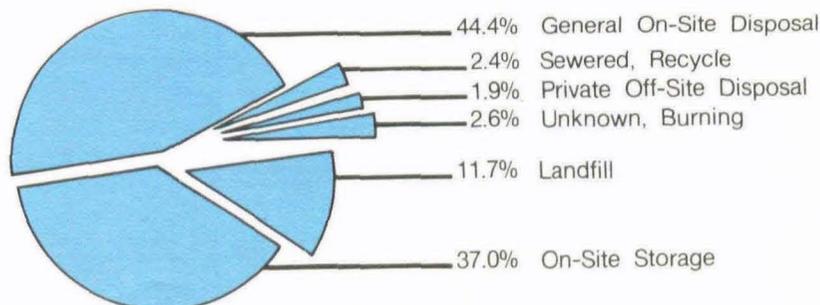
Uncontrolled Hazardous Waste Sites

Unsafe hazardous waste disposal practices become uncontrolled hazardous waste sites, and release of chemicals from these sites can threaten public health or environmental values. (The Love Canal Chemical Dump in New York is a prime example. A school and scores of homes were built close to the dump and, beginning in 1978, a number of startling disclosures about birth defects and serious illness were attributed to the buried chemicals.)

Past hazardous waste disposal practices in the Northwest have been surveyed, and Figure 6 presents the results. Northwest states generate only 1 percent of the hazardous waste nationally, and since 1940, all but approximately 5 percent of these wastes have been accounted for. Over 250 hazardous waste generators and disposal sites have been investigated, and no major problems on the scale of Love Canal have been discovered.

These findings are attributed to the following: hazardous waste generation is minimal; population densities in the Northwest are low; industry is young compared to other areas of the country; and adequate (according to state requirements) hazardous waste disposal sites have been available for several years.

Figure 6.
Hazardous Waste Disposal



Radiation

As Figure 7 shows, every person is exposed to radiation from naturally occurring, inescapable sources such as cosmic rays and soil. Normally, less than half a person's radiation exposure is man-made. The data in Figure 7 are based on national statistics, but are representative for Region 10 as well.

Because the genetic and cancer-causing effects of radiation are thought to be additive or cumulative, the radiation dose to individuals must be kept to the lowest practicable level. EPA limits the radiation dose to individuals and to the total population by monitoring radiation and by setting and enforcing regulations on radioactivity in the air, drinking water, surface water, and waste materials, and from nuclear power plants.

Pesticides

Pesticides are substances used to prevent, destroy, repel, or mitigate any pest, such as insects, rodents, weeds, and fungi, as well as substances used as plant regulators and defoliants. Improperly used, they can harm other organisms besides their target, causing illness or death. The regulation of pesticides poses some complex policy and technical issues. Conventional chemical pesticides, by their very nature, are hazardous; but they are widely viewed as necessary to maintain agricultural productivity. In addition, the hazards of pesticides, especially the long-term effects, are difficult to assess.

The law giving EPA authority to regulate pesticides is the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). It requires that all pesticide producers and all pesticides to be sold in the U.S. (including imported products) be registered with EPA. The pesticide producers must provide scientific studies to support the registered use patterns, and must provide proper container labeling for their products. In addition, they must maintain detailed records of their production and distribution.

The EPA and state agencies work together to regulate the manufacture and use of pesticides. As of this year, EPA has

established funded cooperative enforcement agreements with the Idaho, Oregon, and Washington State Departments of Agriculture, and a non-funded cooperative enforcement agreement with the Alaska Department of Environmental Conservation. This means that primary enforcement responsibilities covering pesticide use rests with the states, but EPA can take further action if warranted.

The major thrust of the FIFRA program is directed toward pesticide users. Since 1976, EPA has worked with the states in developing training and certification programs. Applicators of restricted use pesticides

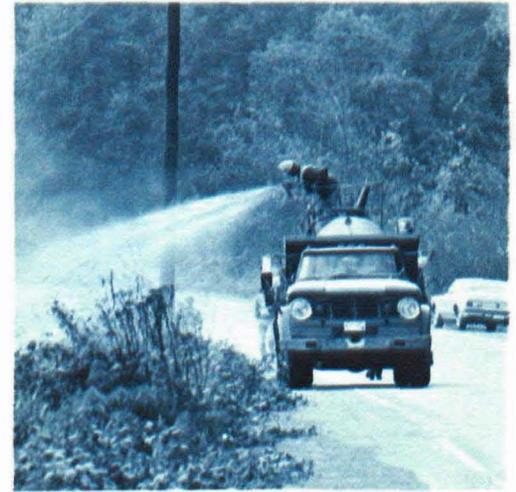
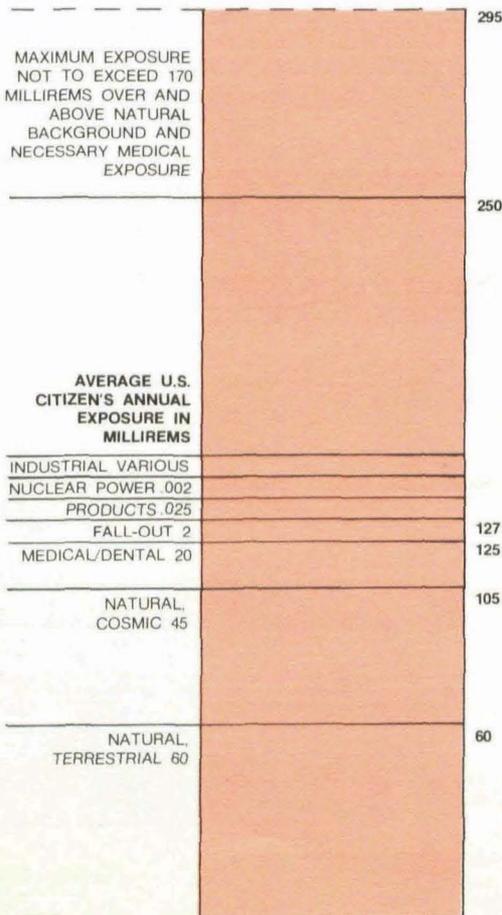


Figure 7. Average Amount of Exposure to Radiation Per Person Per Year



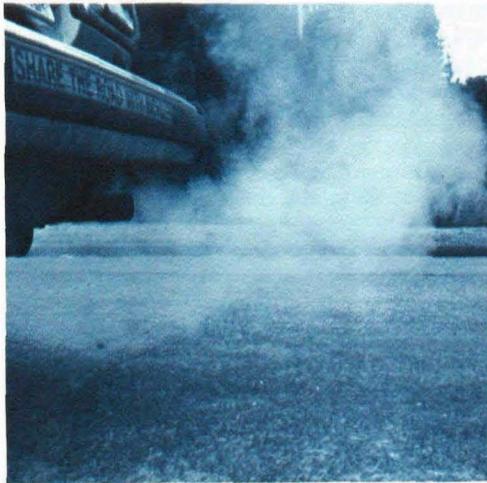
(pesticides with greater potential for causing adverse effects) must be certified to ensure that they are competent in the use of those pesticides. EPA and the states combine efforts to see that pesticides are being used according to label directions.

After pesticides are used, the Food and Drug Administration is responsible for verifying that pesticide residues on raw agricultural commodities are within required limits.

Environmental monitoring for pesticides is conducted by certain state health departments through EPA grants. Region 10 has two epidemiological study groups, one in Wenatchee, Washington and the other in Boise, Idaho.

Pesticide registration and resulting use can be discontinued at any time EPA determines that unreasonable adverse effects on the environment outweigh the benefit from continued use of the pesticide. If further restricting use of the pesticide cannot correct the problems, ultimately the product can be cancelled or suspended. For example, EPA took emergency action to suspend products containing 2,4,5-T and Silvex. Cancellation hearings are in progress and a final determination will be made regarding the future of these pesticides.

Air Quality



Air quality in the Northwest is relatively clean as most areas of the Region comply with the National Ambient Air Quality Standards. However, air quality problems do exist in the more densely populated areas of the four states; but pollution abatement controls on point and area sources should alleviate these problems in the future. Implementation of these controls continues to be a cooperative effort among Federal, state, and local environmental agencies, industry, and a concerned, informed public. However, much remains to be done, and this section gives some insight into the types of air quality problems faced by the citizens of Region 10.

Air Quality Standards — History and Definition

The Clean Air Act of 1970 directed EPA to establish National Ambient Air Quality Standards ("ambient" refers to outside or environmental conditions, rather than indoor quality), and in 1977, amendments to the Act required that all standards be met as soon as possible and practical. In the case of primary (health-related) standards, the new deadline is December 31, 1982. Under certain conditions an extension to December 31, 1987 can be granted for carbon monoxide and ozone.

The more highly concentrated a pollutant, the worse its effect on humans and their

environment. Because some pollutants have both chronic and acute effects on health, standards are based on their average concentration over various lengths of time with a margin of safety included. Pollutants that exceed secondary standards have detrimental impacts on the public welfare and result in deterioration of many consumer products. Exceeding primary standards poses a threat to public health. If the pollutant concentration reaches the alert

level, individuals, industry, and government should take immediate action to protect human health by curtailing outdoor activities, use of automobiles, and certain industrial operations.

Federal standards have been set for six major pollutants. Table 1 lists the effects on health and property that are the normal result of exceeding those standards.

Table 1.
Effects of Major Air Pollutants on Health and Property

| POLLUTANT | HEALTH EFFECTS | PROPERTY EFFECTS |
|------------------------------|--|---|
| Total Suspended Particulates | Correlated with increased bronchial and respiratory disease, especially in young and elderly. | Corrodes metals and concrete; discolors surfaces; soils exposed materials; decreases visibility. |
| Sulfur Dioxide | Upper respiratory irritation at low concentrations; more difficult breathing at moderate concentrations (3000 ug/m ³), correlated with increased cardio-respiratory disease; acute lung damage at high concentrations. | Corrodes and deteriorates steel, marble, copper, nickel, aluminum, and building materials; causes brittleness in paper and loss of strength in leather; deteriorates natural and synthetic fibers; "burns" sensitive crops. |
| Carbon Monoxide | Physiological stress in heart patients; impairment of psychomotor functions; dizziness and headaches at lower concentrations; death when exposed to 1000 ppm for several hours. | Corrodes limestone and concrete structures. |
| Ozone | Irritates eyes, nose, throat; deactivates respiratory defense mechanisms; damages lungs. | Deteriorates rubber and fabrics; corrodes metals; damages vegetation. |
| Nitrogen Dioxide | Combines with hydrocarbons in the presence of sunlight to form photochemical smog; irritates eyes, nose, throat; damages lungs. | Corrodes metal surfaces; deteriorates rubber, fabrics, and dyes. |
| Lead | Primary concern with young children. Most pronounced effects on nervous system (damage may occur at low levels), kidney system, and blood forming system (high levels may have severe and sometimes fatal consequences such as brain disease, palsy, and anemia). Blood levels >30mg/deciliter are associated with an impairment in cell function. | Injures plants through absorption of soil. Affects nervous system of grazing animals. |

How Air Quality is Measured

Air quality data are collected at monitoring stations located throughout each of the four states, primarily in concentrated population or industrial centers—the most likely sources of air pollution. Monitoring sites are designated in this report as commercial/industrial, residential, or rural. However, air pollution can originate away from the monitoring site. High pollutant levels in a residential area, for example, do not necessarily indicate the source is located in that area. Not all pollutants are monitored continuously at all stations, and monitors are not located in all counties, primarily because of the high cost of installation and operation, but monitors are located in large metropolitan areas. EPA has estimated the percentage of days during which concentrations of the various pollutants exceeded the standards throughout Region 10 during 1979.

Geographical areas within Region 10 where source emissions, in combination with influencing weather conditions, cause air quality standards to be exceeded have been designated as *non-attainment*. Currently, 22 areas in Region 10 fall in this category. All other areas are classified as *attainment*. The original determination of non-attainment was based on data for 1975 through 1977; therefore, areas that are presently classified as attainment may have exceeded the standards during calendar year 1979 and are illustrated in this report.

The Regional Air Quality Outlook

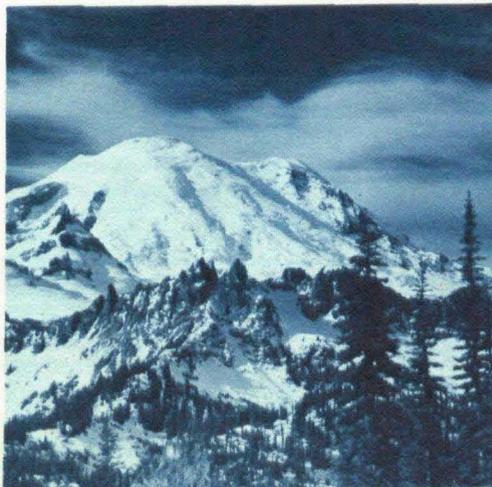
Region 10 has relatively few heavily populated urban centers; in the four states there are only 6.5 million residents. While air pollution is not confined to urban areas, it is most severe where human activity, especially vehicular activity, is heavily concentrated. Some violations of National Ambient Air Quality Standards occur in every state of Region 10.

During 1979, four of the major pollutants exceeded standards in Washington, while three standards were exceeded in both Idaho and Oregon. Only carbon monoxide standards were exceeded in Alaska.

Total Suspended Particulates

Suspended particulates are solid or liquid particles of different sizes having health effects that vary with particle size and composition. Particulates can aggravate *asthma and chronic lung diseases*; they increase coughing and chest discomfort. Some particulates can be toxic or cancer-causing (lead or asbestos particles, for example). Particulate pollution may interfere with visibility, injure vegetation, and increase cleaning and maintenance costs in numerous sectors of the economy.

Suspended particulate matter is a widespread problem throughout the Northwest. Some particulate emissions come from so-called *point sources*, which are easily identified stationary industrial sources of emissions, such as smokestacks. The rest, which cannot be pinpointed to a specific source, are termed *area sources*, such as space heating (residential and commercial heating units) and fugitive dust. Fugitive dust can be created by certain industrial and agricultural operations, and by vehicles on paved as well as unpaved roads. In areas with little major industrial development and low population density, fugitive dust is composed mostly of natural soil particles and is believed to be less harmful to the health. For this reason, many areas are considered to be attaining air quality standards even though particulate standards are exceeded.



Also included under area sources are motor vehicle tailpipe emissions which we have classified separately as mobile sources (see Figure 16, page 17). Figure 8 shows the three states that exceeded suspended particulate standards; i.e., at least one monitoring site in the county exceeded one or more of the standards for total suspended particulates (TSP) in 1979. Aside from areas where rural fugitive dust accounts for exceeding TSP standards, most violations are focused in 16 areas. Data from these areas are charted on Figure 9, showing the percentage of samples that exceeded standards based upon number of days monitored. (Note that particulate samples are routinely collected once every 6 days.)

In Idaho, the Pocatello and Conda-Soda Springs areas' major point sources of total suspended particulates are fertilizer and industrial chemical processors. In the latter area, fugitive dust from roads and fields also contributes to TSP levels in excess of the standards. In Lewiston, the wood products industry and a kraft pulp mill are the chief point sources, while in the Kellogg area, the Bunker Hill Company's smelting operation is a major source of TSP.

In Oregon's Portland area, motor vehicles directly or indirectly account for approximately half the area's suspended particulates; natural sources, vegetative burning, and industrial sources contribute the rest. Wood products, rock products, and metallurgical industries are the major point sources, but all have applied reasonable controls on their emissions. The wood products industry is also the major point source in the Medford-Ashland area. Although the Grants Pass area exceeded TSP standards, more data will be needed to assess potential problems there. In the Eugene-Springfield and Lebanon areas, burning of slash, field stubble, and other vegetation, and airborne dust from roads and fields contribute to particulate levels. Emissions from the wood products, paper, and rock products industries also contribute to the Eugene-Springfield particulate problem.

In Washington's Seattle, Tacoma, and Spokane areas, fugitive dust from paved and unpaved roads and construction sites, and point source industrial emissions caused TSP standards to be exceeded. The main source of particulates in the Vancouver area has been traced to the Carborundum Company, a processor of inorganic minerals. In the Port Angeles and Longview areas, suspended particulate levels are largely due to fugitive dust from log yards

and emissions from the forest products industry. The Clarkston area's major source of pollution is pulp mill operations in Lewiston, Idaho.

Particulate control devices such as baghouses, electrostatic precipitators, and scrubbers have been installed on many industrial sources, and some plants are scheduled to further reduce emissions in the future. As existing plants are modified and

new facilities are constructed, the best technology available to control suspended particulates will be required. Control of fugitive dust is more difficult to achieve. Paving roads and parking areas can help, as well as improved "housekeeping" in industrial areas (such as covering hoppers or conveyor belts or other equipment transporting raw materials). Construction sites can be wetted down to reduce dust. However, it is expected that reduction of fugitive dust will be very gradual due to the high cost of control.

Figure 8.
Air Quality Status —
Total Suspended Particulates

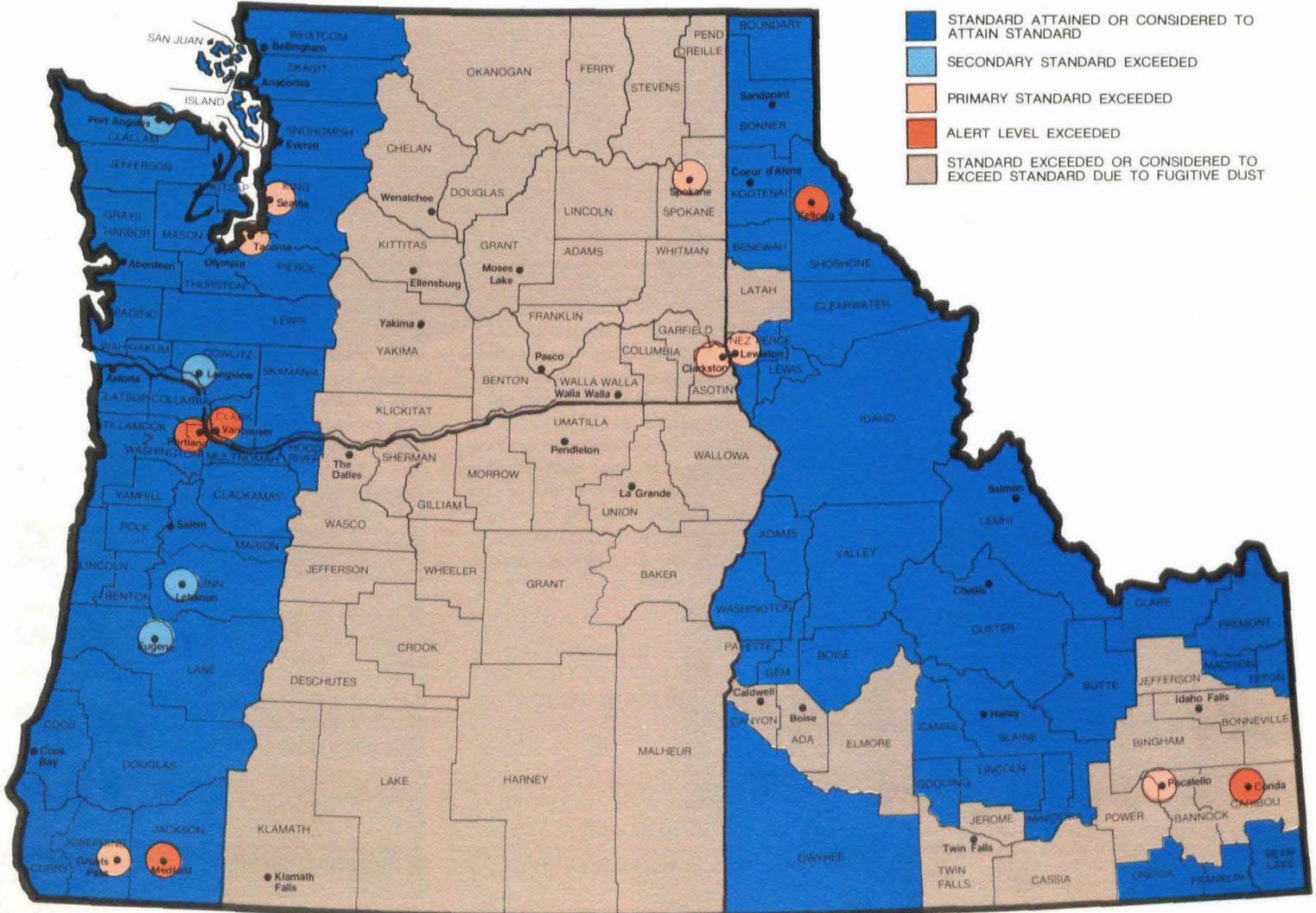
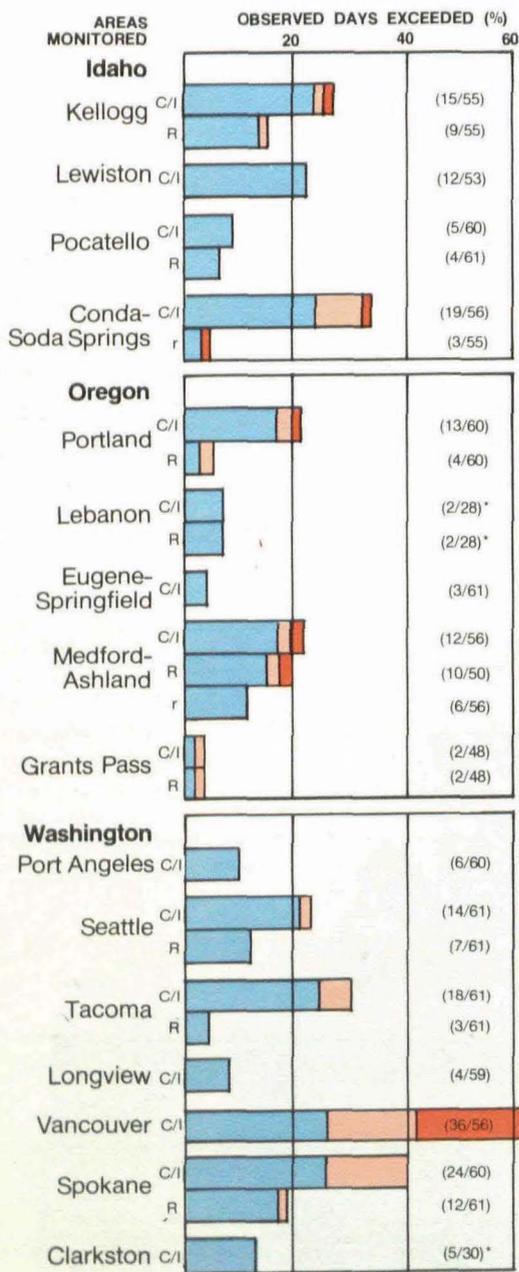


Figure 9.
Percent of Observed Days Total Suspended Particulates Exceeded Standards



NOTE: Number in parentheses represents total number of days exceeding standards per number of observation days.

*May not be representative of total problem. Less than 75% of observation days reported.

Alaska is not illustrated in Figures 8 and 9 since violations in the state are attributed to fugitive dust. However, the Fairbanks, Alaska area has a unique pollution problem called "ice fog" which forms spontaneously at -40°F when supersaturated water vapor cools and can no longer hold moisture, forming ice crystals. At warmer temperatures, -20°F , ice fog can form around condensation nuclei such as particulate matter. Deeper layers of ice fog have been forming more frequently at warmer temperatures as the population has increased, with heavy ice fog occurring approximately 15 days per year. There is no Federal air quality standard pertaining to ice fog even though it severely decreases visibility. Economical control techniques are presently being researched and evaluated to help reduce this problem.

To date, the concern in Region 10 has been to reduce emissions from point sources. Although most of the industries that produce significant amounts of particulates have installed the required control devices, particulate problems, especially those resulting from area sources, still remain in the urban areas.

Sulfur Dioxide

Sulfur dioxide is formed when coal or oil containing sulfur is burned, or when sulfur is burned in an industrial process. Breathing air containing sulfur dioxide can produce adverse health effects similar to those described above for suspended particulates. When sulfur dioxide combines with moisture in the air to form acidic mist and rain, it can pose an increased health hazard. In addition, it corrodes buildings, is harmful to vegetation, and can deteriorate the water quality of lakes and streams far from the source of the pollutant.

Figure 10 shows the air quality status of sulfur dioxide in Region 10 and Figure 11 compares those areas that exceeded

C/I: COMMERCIAL INDUSTRIAL
 R: RESIDENTIAL
 r: RURAL

■ SECONDARY STANDARD EXCEEDED
 ■ PRIMARY STANDARD EXCEEDED
 ■ ALERT LEVEL EXCEEDED

standards. In Idaho, the principal cause of sulfur dioxide pollution is the smelting of nonferrous ores (lead and zinc) and the manufacture of phosphate fertilizer.

In Kellogg, where the Bunker Hill Company smelts and refines lead and zinc, the rugged terrain of the Silver Valley inhibits adequate dispersion of sulfur dioxide, although the plant's two 700-foot stacks have improved the situation. However, during frequent thermal inversions, the plant must follow a set of procedures to reduce or discontinue production to keep sulfur dioxide levels within the standards. The Bunker Hill Company will conduct further studies to determine where maximum sulfur dioxide concentrations occur. The results of these studies will provide the information necessary to improve Bunker Hill's dispersion program to meet ambient standards until additional controls are installed.

The major source of sulfur dioxide in the Pocatello area is J.R. Simplot, which produces fertilizers and industrial chemicals. The company is installing additional controls that should further reduce their emissions by 25 percent. The Beker Industries phosphate fertilizer plant near Soda Springs is the major source of sulfur dioxide in that area; primary sources are two sulfuric acid plants, both of which operate in compliance with applicable emission regulations when their control equipment is functioning properly.



Over 80 percent of Washington's sulfur dioxide pollution comes from industrial sources and power plants. About half the emissions in the state are from ASARCO's Tacoma smelting and refining operations; however, violations of standards have not occurred in Tacoma since December 1976. ASARCO relies on dispersion techniques to

meet national ambient air quality standards by reducing operations when weather conditions (such as thermal inversions) prevent adequate mixing. As in the case of the Bunker Hill smelter, this may only be a temporary solution until the need for better, constant control has been established and equipment installed.

The major sulfur dioxide sources in the Port Angeles area are ITT Rayonier and Crown Zellerbach. Based on meteorological conditions, emission rates, and the geography of the area, ITT appears to have the dominant effect on ambient sulfur dioxide levels.

The pulp mills in southeastern Alaska, major point sources of sulfur dioxide, comply with the state's SO₂ air quality regulations. In 1979, the sulfur dioxide standards were not exceeded. Additional data are needed to assess potential future sulfur dioxide problems that could arise from operation of the pipeline terminal and proposed construction of a petrochemical plant in Valdez.

Oregon complies with the National Ambient Air Quality Standards for sulfur dioxide and there are no known potential problems in that state.

Figure 10.
Air Quality Status — Sulfur Dioxide

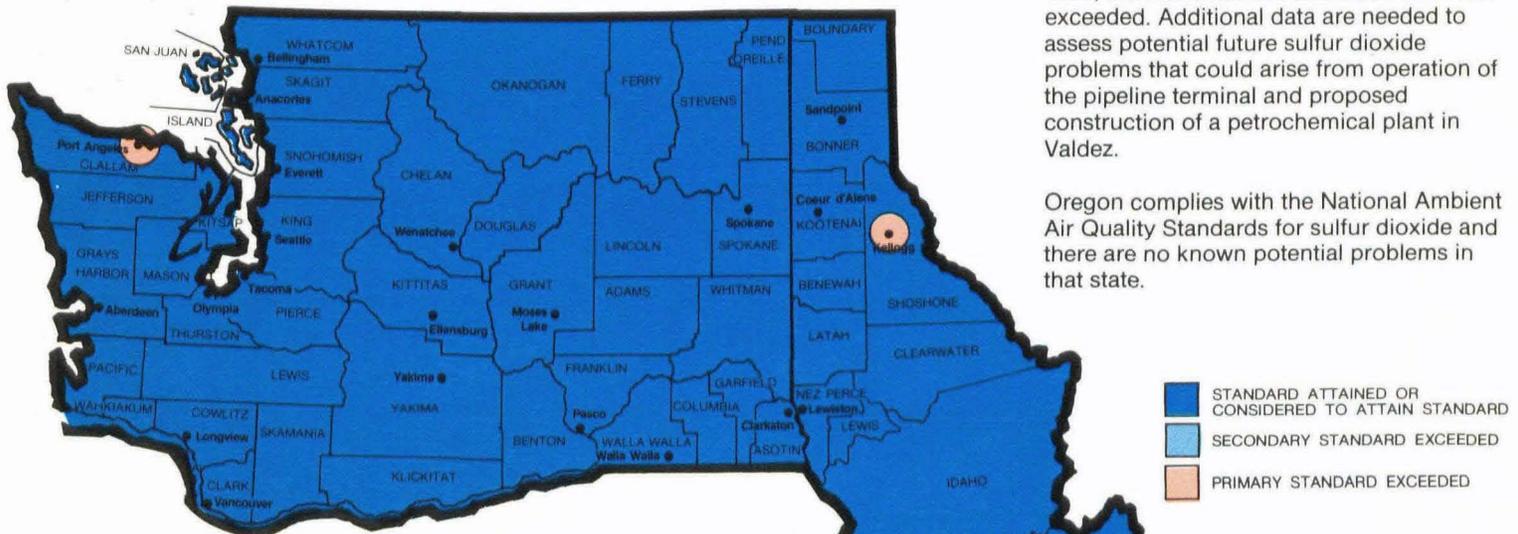
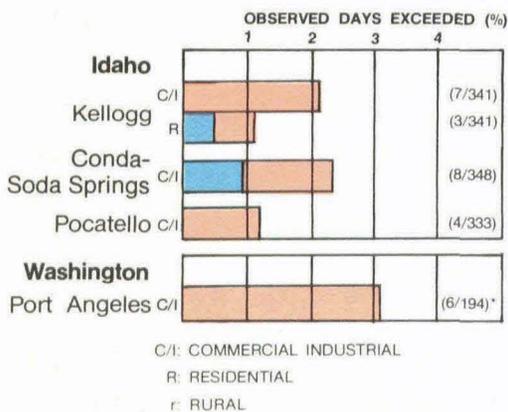


Figure 11.
Percent of Observed Days Sulfur Dioxide Exceeded Standards



NOTE: Number in parentheses represents total number of days exceeding standards per number of observation days.
*May not be representative of total problem. Less than 75% of observation days reported.

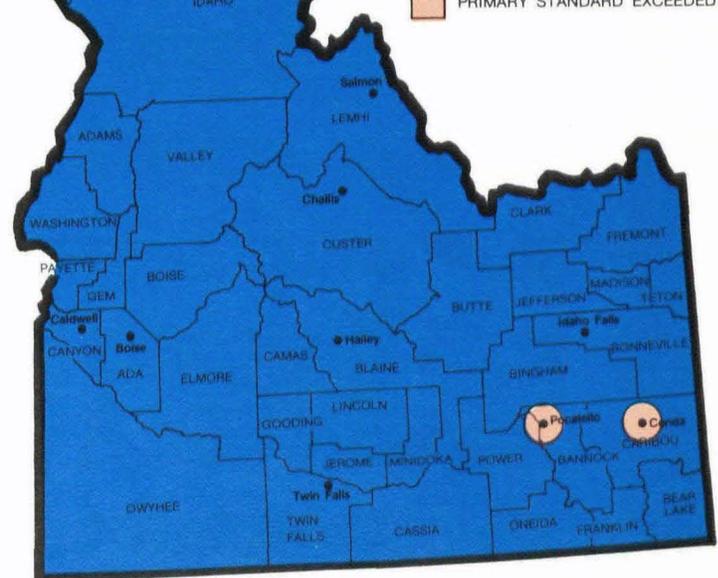
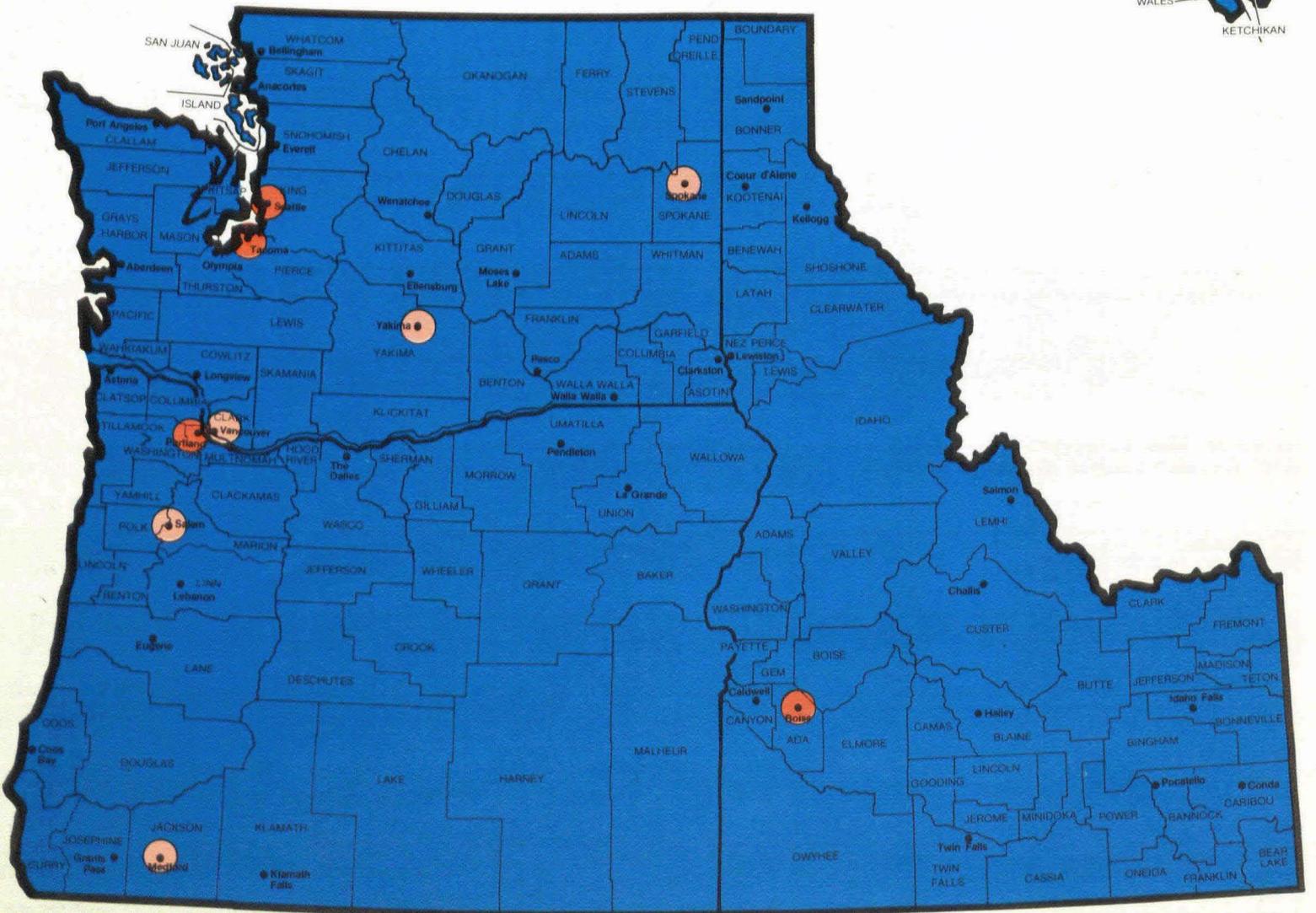
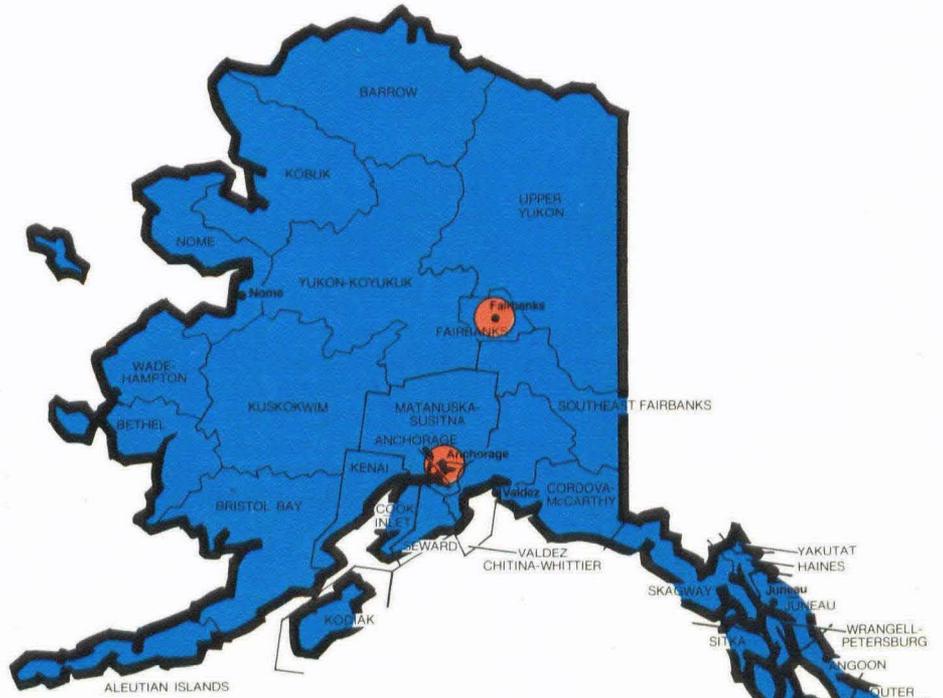


Figure 12.
Air Quality Status — Carbon Monoxide

- STANDARD ATTAINED OR CONSIDERED TO ATTAIN STANDARD
- PRIMARY STANDARD EXCEEDED
- ALERT LEVEL EXCEEDED



Carbon Monoxide

Carbon monoxide is a colorless, odorless gas—high concentrations can cause unconsciousness or even death. At concentrations above the primary standard, this pollutant can interfere with mental alertness and physical activity, especially for persons with heart or lung disorders. Carbon monoxide is a by-product of fossil fuels combustion. Its major source is motor vehicles, and the most severe violations of standards are recorded where automobiles are concentrated—in urban areas. Figure 12 illustrates the extent of the carbon monoxide problem in Region 10, and Figure 13 compares the areas not meeting the carbon monoxide standard.

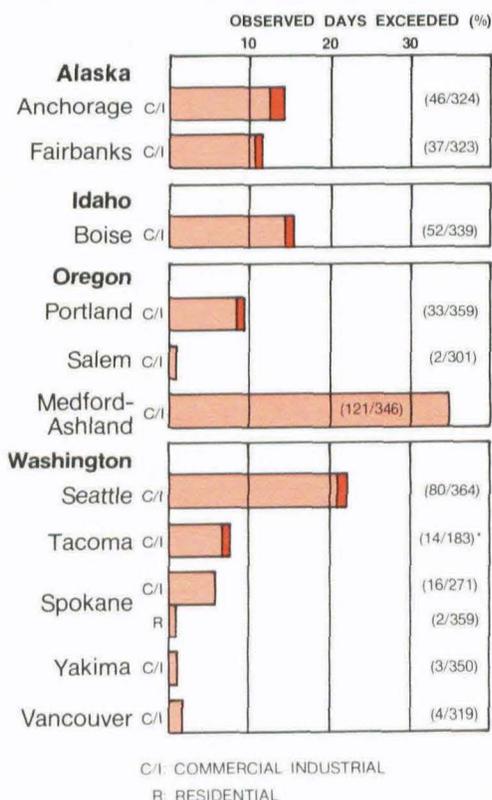
Motor vehicles are responsible for about 90 percent of carbon monoxide emissions; therefore, plans for reducing such emissions center on improvements to individual automobiles and to the transportation system as a whole. As older cars are replaced by models with up-to-date pollution control equipment, carbon monoxide levels should decline. In addition, regular vehicle inspection and maintenance will ensure that emission control devices are functioning effectively. Other measures for mitigating the carbon monoxide problem are based upon reducing vehicle miles traveled and include traffic flow improvements, transit improvements, carpooling, bike lanes, and parking management.

The majority of the carbon monoxide problems in Region 10 are compounded by adverse climate conditions. During the winter months, extreme stable inversions develop in many parts of the Region which severely inhibit the dispersion characteristics of pollutants resulting in high pollutant concentrations. Also, it is difficult to maintain efficient combustion processes in cold weather. For example, automobiles in Alaska take longer to warm up and emit substantially more air pollutants than at warmer ambient temperatures; carbon monoxide emissions during engine warm-up may account for up to 65 percent of the total vehicle emissions produced, depending upon the size of the engine. Therefore, maintaining a warm engine or reducing average engine size may be effective in reducing cold-start emissions. These

emissions are currently uncontrolled, and the proposed low-temperature emission standard for automobiles should be effective in helping to achieve the 90% reduction mandated by the Clean Air Act through the Federal Motor Vehicle Control Program.

Through transportation controls previously identified, EPA is working closely with the Region 10 states to control emissions from vehicles and to reduce the number of vehicle miles traveled in urban centers with high carbon monoxide levels.

Figure 13.
Percent of Observed Days
Carbon Monoxide Exceeded Standards



NOTE: Number in parentheses represents total number of days exceeding standards per number of observation days.

*May not be representative of total problem. Less than 75% of observation days reported.

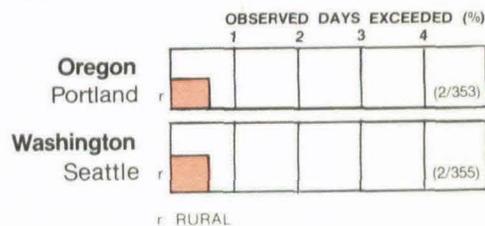
■ ALERT LEVEL EXCEEDED
■ PRIMARY STANDARD EXCEEDED

Ozone

Unlike other air pollutants discussed in this report, photochemical oxidants are not emitted by industries or automobiles; rather, they are the product of a chemical reaction that occurs in the atmosphere when two other pollutants are present—oxides of nitrogen (which are discussed below) and hydrocarbons. The chief sources of hydrocarbons include automobile exhaust and volatile organic compounds (VOC) such as solvents and gasoline. Besides oxides of nitrogen and hydrocarbons, sunlight is necessary for the reaction. When all three are present, a class of chemicals known as photochemical oxidants is produced, the most common of which is the gas, ozone. Air quality standards refer to ozone, and only ozone is measured by monitoring instrumentation.

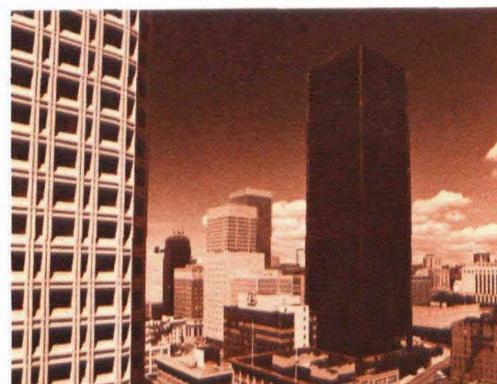
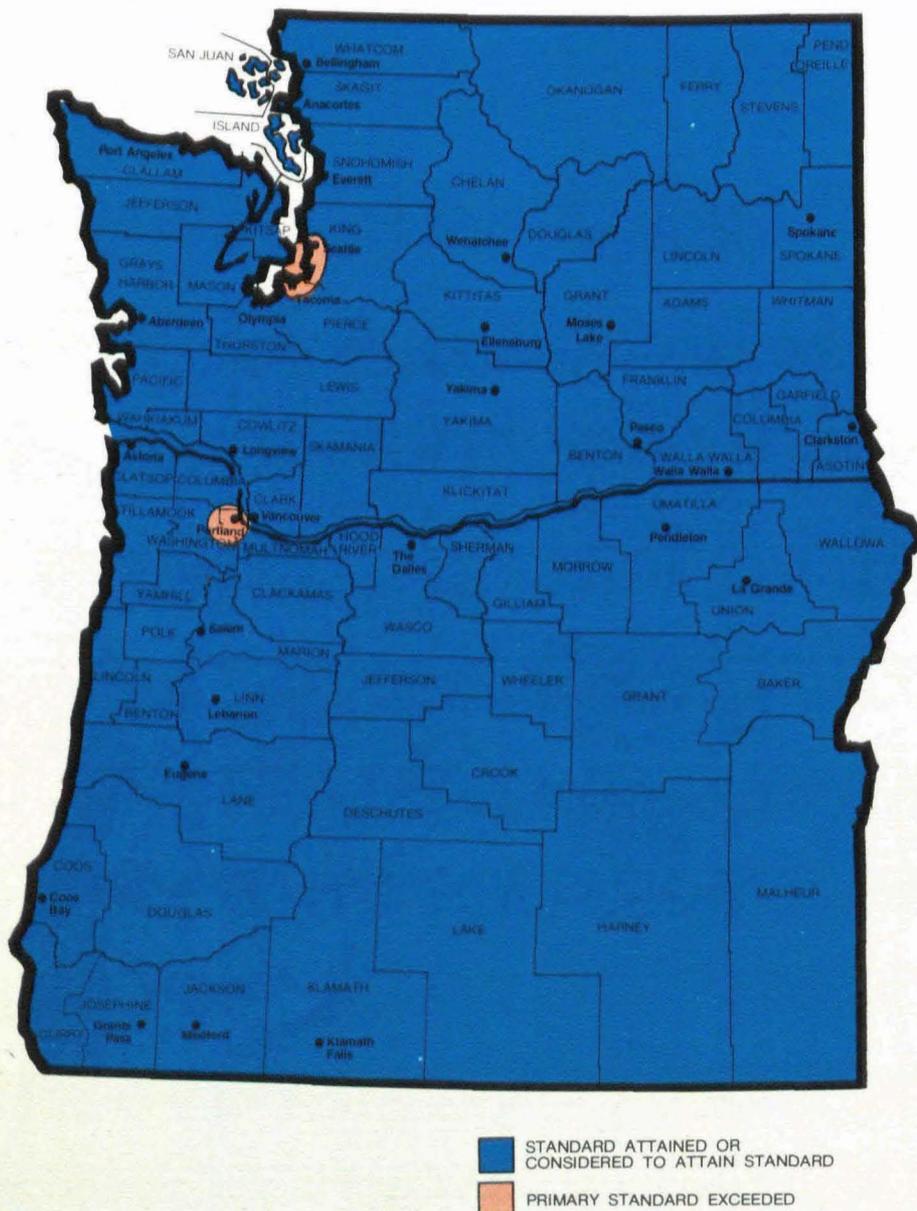
Ozone irritates the eyes and respiratory system, aggravates asthma and chronic lung diseases, and reduces lung and heart capacity. It also probably causes more damage to plants in the United States than any other pollutant. Ozone concentrations greater than the health standard have occurred in the Portland, Oregon, and Seattle, Washington, areas, (see Figures 14 and 15) and future monitoring may identify other areas. Because significant quantities of the substances that give rise to ozone come from automobiles, measures taken to reduce other automobile emissions, such as carbon monoxide, are also effective in controlling ozone. Also, measures that control VOC indirectly lower ozone levels. (An example is the floating roof for oil storage tanks that reduces evaporative losses.)

Figure 14.
Percent of Observed Days
Ozone Exceeded Standards



NOTE: Number in parentheses represents total number of days exceeding standards per number of observation days.

Figure 15.
Air Quality Status — Ozone



Nitrogen Dioxide

Oxides of nitrogen are gases formed mainly by combustion. Sources include automobiles and power plants. Besides irritating the eyes and respiratory tract and damaging metal, rubber, fabric, and dyes, oxides of nitrogen contribute to photochemical oxidants, as described above.

During 1979, the nitrogen dioxide standard was not exceeded in any of the Region 10 states.

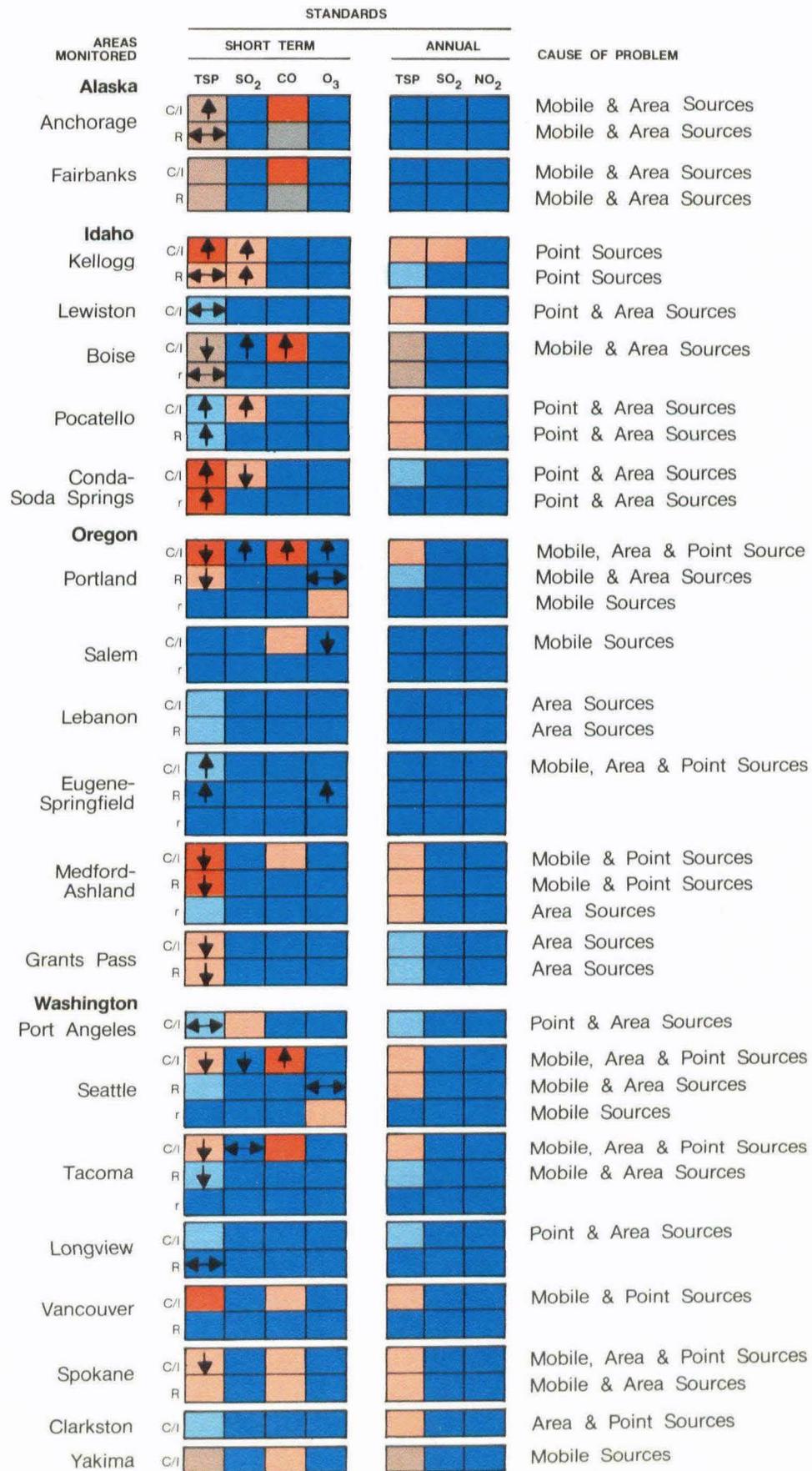
Lead

In 1978, EPA established an air quality standard for lead, which is to be achieved by November, 1982. At this time, the states, in cooperation with EPA, are gathering data to identify areas where the standard is being exceeded. Violations of the lead standard have occurred in the Kellogg, Idaho, area where the major sources are the Bunker Hill Company's lead smelter and general areawide contamination resulting from 60 years of milling and smelting operations. Lead violations have also been found in the Seattle, Washington, area—Harbor Island due to RSR/Quemetco and along Interstate 5 from Northgate to Spokane Street. The Puget Sound Air Pollution Control Agency is developing a plan to clean up the Seattle area.

Other Hazardous Materials

In addition to the six major air pollutants discussed above, other hazardous materials emitted to the air include asbestos, beryllium, and mercury. EPA is analyzing other potentially hazardous pollutants, and standards for these will be developed in the future, if necessary.

Figure 16.
Air Quality Trends

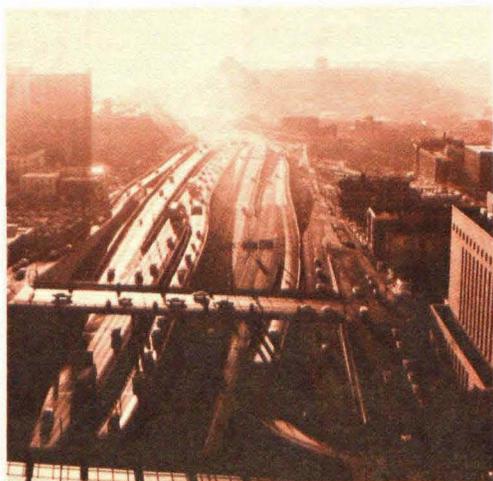


Trends in Air Quality

Trends in air quality indicate whether air pollution control activities have been effective. Figure 16 shows the urban areas in Region 10 in which air quality standards were exceeded in 1979. A trend was established for designated monitoring sites obtaining data for the 6-year period from 1974 through 1979. Air quality has improved in some Region 10 areas over the past few years; however, those improvements may not be shown in Figure 16 because long-term trend data is lacking. Also, new sites have been added within the last year to state networks, and trends for these areas will be available in the future.

C/I: COMMERCIAL INDUSTRIAL
R: RESIDENTIAL
r: RURAL

- STANDARD ATTAINED OR CONSIDERED TO ATTAIN STANDARD
- SECONDARY STANDARD EXCEEDED
- PRIMARY STANDARD EXCEEDED
- ALERT LEVEL EXCEEDED
- STANDARD EXCEEDED OR CONSIDERED TO EXCEED STANDARD DUE TO FUGITIVE DUST
- INSUFFICIENT DATA BUT CONSIDERED TO EXCEED STANDARD
- ↑ IMPROVING TREND
- ↓ DETERIORATING TREND
- ↔ NO SIGNIFICANT CHANGE



River Water Quality



Water quality in Pacific Northwest and Alaskan rivers is generally good; however, portions of many Region 10 major rivers have marginal quality with respect to Federal water quality goals. This degradation is the result of both point and non-point sources of pollution with some problems attributed to natural causes. Criteria most often exceeded are those for temperature, bacteria, nutrient levels, and heavy metals. To attain the water quality goals, wastewater treatment programs for point sources and best management practices for non-point sources either have been implemented or are planned.

How River Water Quality is Determined

When Congress enacted amendments to the Federal Water Pollution Control Act in 1972, a national goal was set—"fishable, swimmable" waters by 1983 and the states in Region 10 have adopted that goal. The purpose of the Act is to protect the quality of our Nation's waters for a variety of uses, including public water supply, wildlife, fish and shellfish, recreation, navigation, agriculture, and industry. Each water use depends on certain characteristics, such as temperature, concentration of dissolved oxygen, or absence of bacteria, which can be measured and used to evaluate water quality. They vary with the chemistry of the stream being measured, the season, and other factors.

Region 10 states have specified a limited number of criteria for water quality parameters and incorporated them into water quality standards. In addition, to reliably compare water quality on a regional scale, EPA Region 10 developed a standardized set of parameters and associated criteria and segregated them into ten related groups (Table 2). These criteria are a synthesis of state water quality standards, National EPA water quality criteria, information in technical literature, and professional judgment. Like the state water quality standards, this more

comprehensive set of criteria is intended to define water quality levels necessary to protect human and aquatic life and the desired recreational uses of river and stream waters, and thus represent EPA Region 10 water quality goals. More than one criteria value based on water use may be associated with certain parameters. For example, most of the Region's streams are managed to support cold water game fish species such as trout and salmon; however, some are managed as warm water fisheries, supporting bass, bullhead, etc., which require less stringent criteria. The water

Table 2.
Criteria Categories for the
Water Quality Index

| CRITERIA CATEGORY | EXPLANATION |
|-------------------------------|---|
| Temperature | Water temperature influences the type of fish and other aquatic life that can survive in a river. Excessively high temperatures are detrimental to aquatic life. |
| Dissolved Oxygen | To survive, fish and aquatic life must have certain levels of oxygen in the water. Low oxygen levels can be detrimental to these organisms. |
| pH | pH is the measure of acidity or alkalinity of water. Extreme levels of either can imperil fish and aquatic life. |
| Aesthetics | Refers to oil, grease, and turbidity which are visually unpleasant. For the Index, this group is mostly represented by the turbidity parameter, which is a measure of the clarity of the water, because it is much more widely measured than any of the others within the group. |
| Solids | Dissolved mineral and suspended material such as mud or silt. Excess dissolved minerals (hard water) interfere with agricultural, industrial, and domestic use. Excess suspended solids adversely affect fish feeding and spawning. |
| Radioactivity | May be in water as a result of radioactive waste discharges or fallout. Excess levels can harm aquatic and other life forms. |
| Bacteria | Bacteria indicate probable presence of disease-related organisms and viruses not natural to water (i.e. from human sewage or animal waste). |
| Trophic (Nutrient Enrichment) | Indicates the extent of algae or nutrients in water. Nutrients promote algae growth. When algae (one-celled water plants) flourish they make the water murky, and the growths make swimming and fishing unpleasant. Decomposition of dead algae can decrease dissolved oxygen concentrations to levels harmful to fish. |
| Organic Toxicity | Includes pesticides and other organic poisons having same effects and persistence as pesticides. |
| Inorganic Toxicity | Heavy metals and other elements; excess concentrations are poisonous to aquatic and other life forms. Also includes percent saturations of dissolved gases in water which can affect the metabolism of aquatic life. |

Approximately 80 parameters were evaluated and condensed to the 10 categories shown here. More detailed information is available on request.

quality of an individual stream or stream portion may be determined at a monitoring station by measuring each parameter and comparing it to the criteria. But to compare one stream to another, or to compare segments within a particular stream, a single inclusive number is useful. Consequently, a Water Quality Index (WQI) has been formulated by EPA Region 10 based upon the aforementioned criteria.

Sources and Control of Water Pollution

Pollutants that reach the Region's streams have two general origins: *point source* pollution, such as wastewater from industries, sewage treatment plants, and the like, that enters streams at an easily identified location; and less easily identified *non-point source* pollution, that consists of stormwater from urban areas, irrigation water, and runoff from farm, forest, and mining lands.

Industries that discharge waste effluent to streams must have a permit issued by EPA under the National Pollution Discharge Elimination System (NPDES) or by states that have assumed this responsibility. Through this means, EPA can require that point source pollutants be removed before wastewater reaches the river. Since non-point sources cannot be so easily treated, "best management practices" are required. For example, agricultural best management practices might include waste storage areas to keep organic wastes from reaching nearby streams, or contour plowing to prevent erosion of soil into rivers.

The responsibility for developing methods to control non-point source pollution has been given to local and state agencies assigned to develop water quality management plans as provided by the Federal Water Pollution Control Act.

Water Quality Index

In this report, the Water Quality Index compares water quality data measured, primarily, from October 1977 through September 1979 with the recommended Federal criteria. (Water management agencies usually operate on a "water year," i.e., October-September, rather than on a calendar year basis.) This data is collected by various Federal, state, and local agencies and stored in EPA's computer systems. The final Index number for each station takes into account the 10 water quality criteria categories shown in Table 2, adjusted to reflect the severity by which the criteria are exceeded. Two types of Index numbers are generated: one represents the average annual water quality, the other shows the worst 3 consecutive months status, which provides a better indication of the severity of those water quality problems occurring on a seasonal basis. The Index numbers span a scale from 0 (no measured evidence of pollution) to 100 (severe pollution at all times). In this report, the scale is divided into three color ranges:

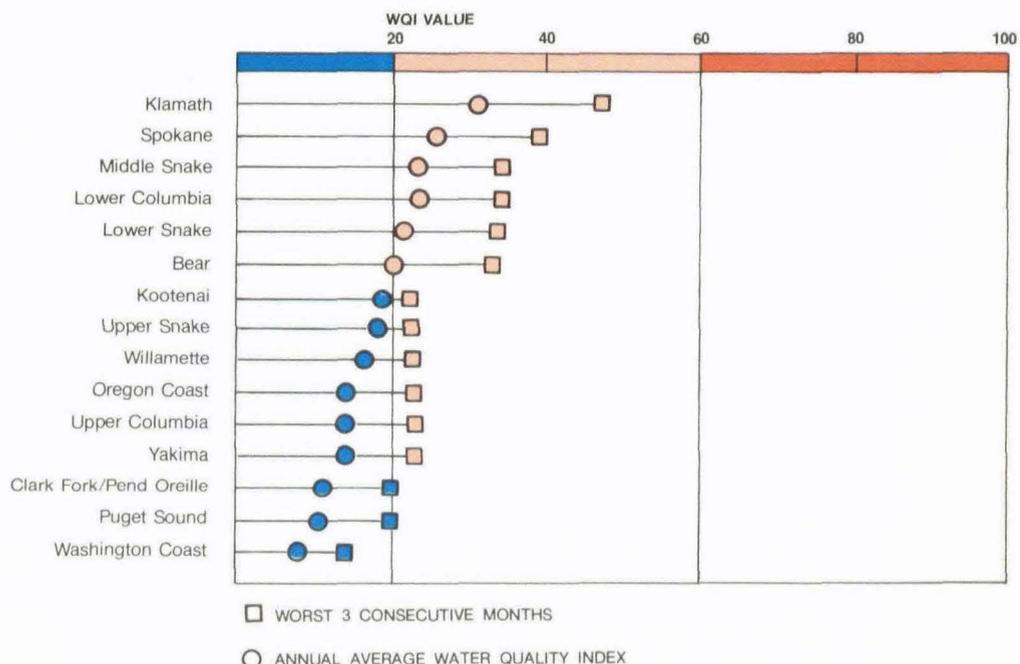
Blue represents streams with Index numbers between 0 and 20. These streams either have no pollution or are minimally polluted and therefore meet the goals of the Federal Water Pollution Control Act.

Light brown represents streams with Index numbers between 20 and 60. Such streams are intermittently and/or moderately polluted and are considered marginal with respect to meeting the goals of the Act.

Dark brown represents streams with an Index number greater than 60. These streams are severely polluted and do not meet the goals of the Act.

The color gray is used in the graphs when the water quality status is unknown because of inadequate data.

Figure 17. Water Quality Index Values for Principal Region 10 River Basins



Lack of data precludes calculation of WQI values for Alaska basins.

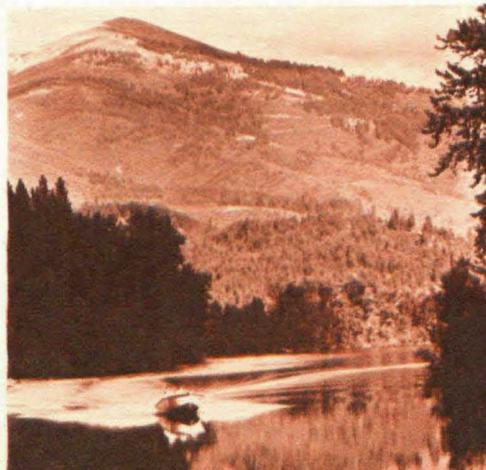
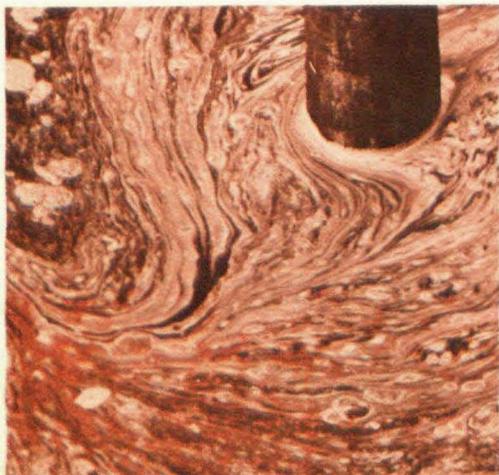
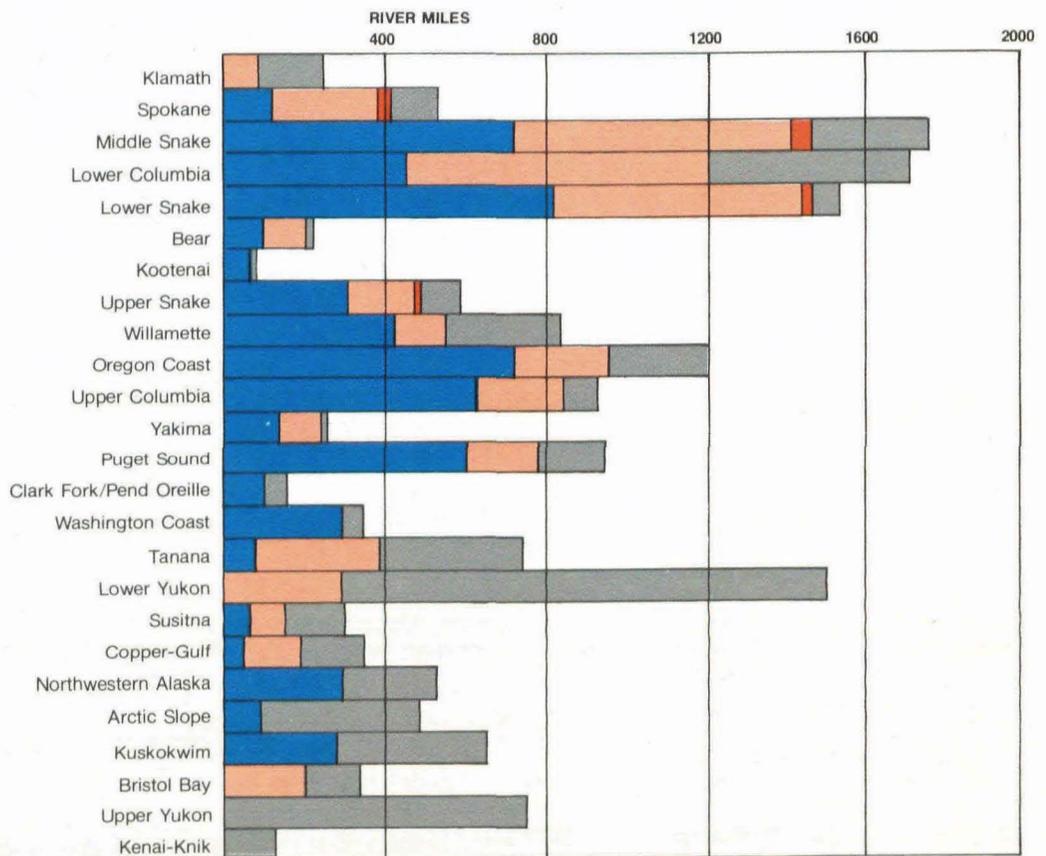
- UNACCEPTABLE — SEVERE POLLUTION
- MARGINAL — INTERMITTENT, OR MODERATE POLLUTION
- ACCEPTABLE — MINIMAL, OR NO POLLUTION

The Regional Overview

The Water Quality Index is used in Figure 17 to compare the major river basins, which include the principal rivers and tributaries within Idaho, Oregon, and Washington. (Lack of data precludes the calculation of WQI values to represent entire Alaska basins.) Figure 18 depicts the relative extent of water quality degradation within each river basin, and Figure 19 shows similar information on a regional map. Only three major river basins (Figure 17) seem to clearly meet the Federal water quality goals, with both Index numbers less than 20. Another six generally meet the goals, except during certain times of the year. The remaining six basins only marginally meet the Federal goals, and the majority of these drain arid portions of the Region that receive significant non-point source waste contributions from agricultural and livestock activities.

Most of the criteria exceeded are those for temperature, bacteria, trophic, aesthetics, solids, and inorganic toxicants categories. Natural conditions such as hot summer temperatures, low streamflows, and easily erodable soils also contribute, particularly in the more arid portions of the Region. In the Spokane River Basin, high heavy metals contributions from past and present mining activities on the South Fork Coeur d'Alene River drainage in Idaho are primarily responsible for elevated Index values. Elevated heavy metals concentrations of unknown origins also appear in portions of the Lower Columbia and Lower Snake Basins.

Figure 18.
Miles Within Principal Region 10
River Basins Meeting Water Quality Criteria



BASED UPON THE AVERAGE ANNUAL WQI:

- UNACCEPTABLE — SEVERE POLLUTION
- MARGINAL — INTERMITTENT, OR MODERATE POLLUTION
- ACCEPTABLE — MINIMAL, OR NO POLLUTION
- STATUS UNKNOWN

Only the principal river and tributary mileages are shown for each basin.

Figure 19.
Water Quality Status of Principal Rivers in
Region 10 (Based Upon the Average
Annual WQI)

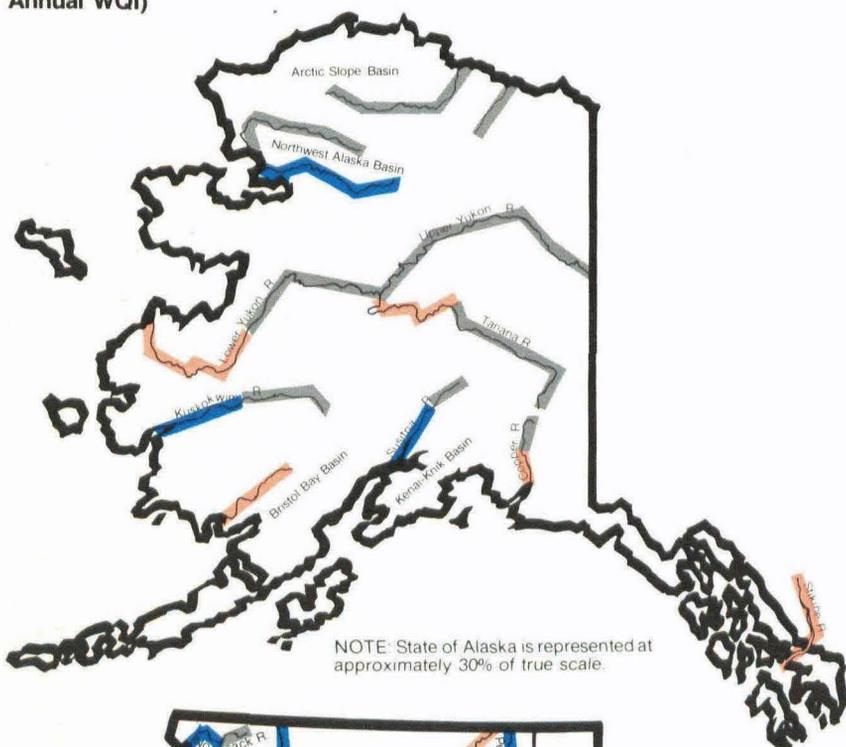
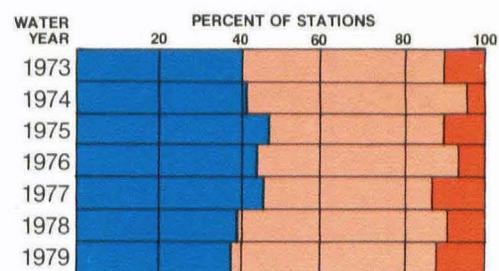


Figure 20.
Water Quality Trends in Region 10



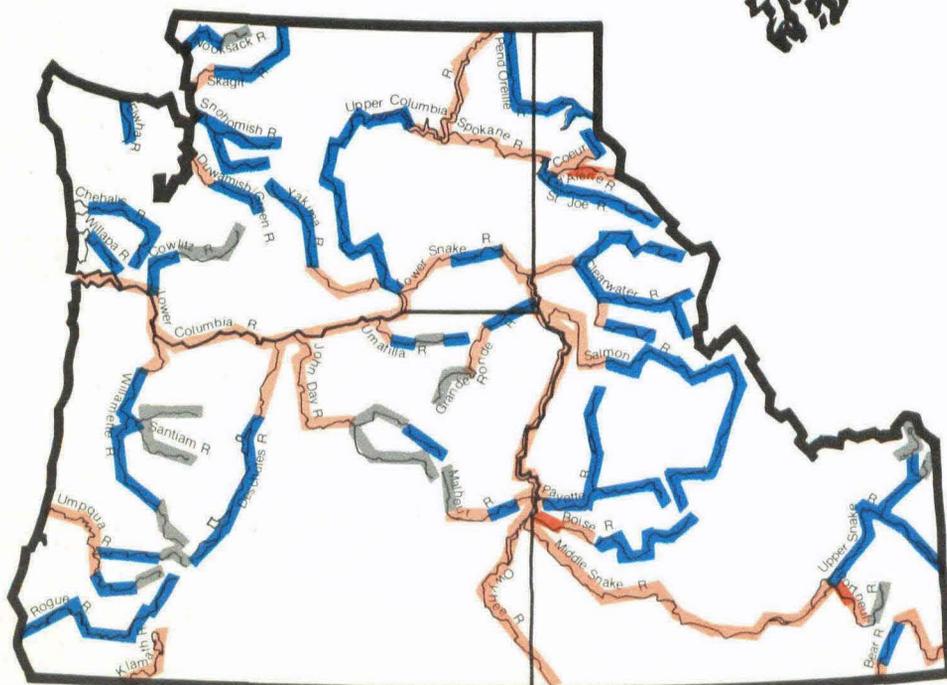
Based upon the water quality status during the worst 3 consecutive months per station at 89 monitoring and stations within Region 10. (Alaska stations, organic and inorganic toxicant pollution categories not included.)

- █ UNACCEPTABLE — SEVERE POLLUTION
- █ MARGINAL — INTERMITTENT, OR MODERATE POLLUTION
- █ ACCEPTABLE — MINIMAL, OR NO POLLUTION
- █ STATUS UNKNOWN

Data on organic toxicants is lacking for most streams. Programs are underway, however, to better define their extent and to develop realistic criteria for these compounds.

Most of the criteria exceedances indicated in Alaska are due to natural conditions, such as glacial activity and spring runoff. Past and present mining operations may be contributing to the higher solids and metals values in some of these rivers.

Regional water quality trends were analyzed by comparing data from 89 representative monitoring stations over a 7-year period (Figure 20). There has been little significant change at these stations since 1973. Due to inadequate data, Alaska rivers could not be included in the analysis, nor were organic or inorganic toxicants included, since there have been significant changes in analytical techniques and reporting procedures over the time period considered. Although point source controls have made many improvements in Regional water quality, further plans to identify and control non-point sources are needed to improve water quality in those stream segments still not fully meeting water quality goals.





The Quality of Oregon's Principal Rivers

Figures 21 and 22 show that none of Oregon's principal rivers and streams are severely polluted all year. The Snake River above Brownlee Dam (Middle Snake) experiences severe degradation during some months of the year. Portions of the Owyhee and Malheur Rivers are seasonally polluted to almost as great a degree. Half of the principal rivers have only marginal water quality on an annual average basis, and more are similarly affected at least part of the year. Most of the lesser quality streams are located in the eastern and southern parts of the state, and are impacted by non-point source wastes from irrigation, agricultural, and livestock activities.

Figure 23 shows the worst 3-month status of certain Oregon river and stream reaches with respect to each of the 10 WQI categories. Some of the man-caused sources of criteria exceedances are also indicated. Criteria most frequently exceeded are temperature, bacteria, trophics, solids, and inorganic toxicants (basically, heavy metals).

Temperatures exceeding the criteria contribute to the impairment of cold water fish species. This condition is somewhat mitigated by the ability of the fish to migrate to cooler tributary streams during the warmest periods, and to partially adapt to the warmer temperatures. The hot, dry climate in eastern and southern Oregon with attendant low streamflows is mostly responsible for these

exceedances. In some streams, however, these climatic conditions may be aggravated by irrigation diversions and return flows, dams, and the destruction of streambank vegetation. The portions of the Malheur, Owyhee, Umatilla, and Klamath that are represented were evaluated against warm water fishery criteria and subsequently do not indicate temperature exceedances.

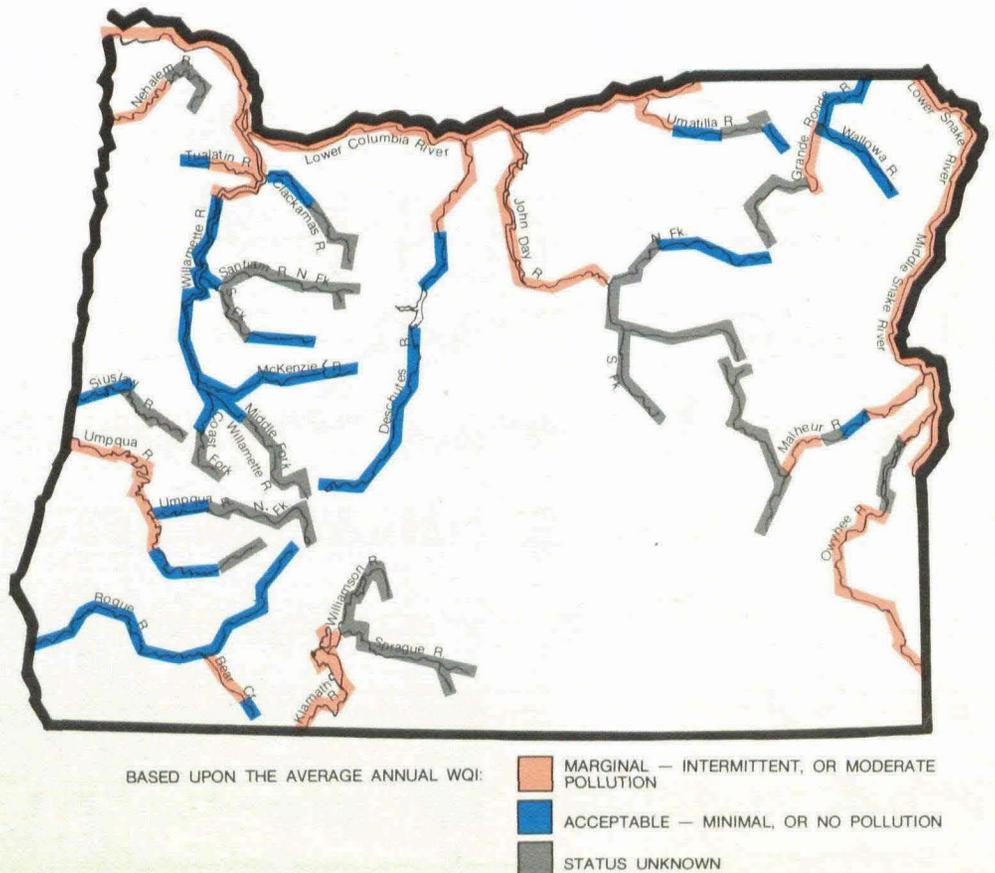
Dissolved oxygen levels occasionally failed to meet the criteria in the Snake River immediately below Hell's Canyon Dam and in the Klamath River near Keno. This is due to the introduction of nutrients from agricultural, livestock, and natural sources, which stimulate algal and aquatic weed growth during the spring and summer months. The subsequent decay of these growths and other organic

debris introduced by irrigation wastewater consumes quantities of dissolved oxygen sufficient to cause the remaining oxygen levels to fall short of the criteria. In the lower South Umpqua, low dissolved oxygen levels appear to be caused by municipal point sources combined with seasonally low streamflows during the summer.

The lower John Day and Middle Snake Rivers show pH values in excess of the criteria. Natural soil conditions may be the primary reason in the former case, and agricultural runoff in the latter.

Over half of the stream segments shown exceed criteria levels for bacteria and nutrients. Much of this degradation may be attributed to runoff from grazing lands,

Figure 21.
Water Quality Status of Oregon's Principal Rivers



croplands, and animal confinement areas. Municipal point sources also contribute to these problems in certain areas.

In Region 10, the aesthetics and solids categories are mostly represented by the turbidity and suspended solids parameters, respectively, and are therefore closely related. High turbidity levels usually indicate similar levels of suspended solids, which are caused by the erosion of soil into the rivers and streams. Both conditions are aesthetically offensive. Most of those Oregon streams exceeding the turbidity criteria are impacted by agricultural runoff during late spring and summer. The other streams are affected to a lesser extent during winter and spring due to

rainfall and snowmelt runoff. Again, although many of these conditions are probably natural in origin, man's agricultural, livestock, and forestry activities across the state may be responsible for some of the degradation.

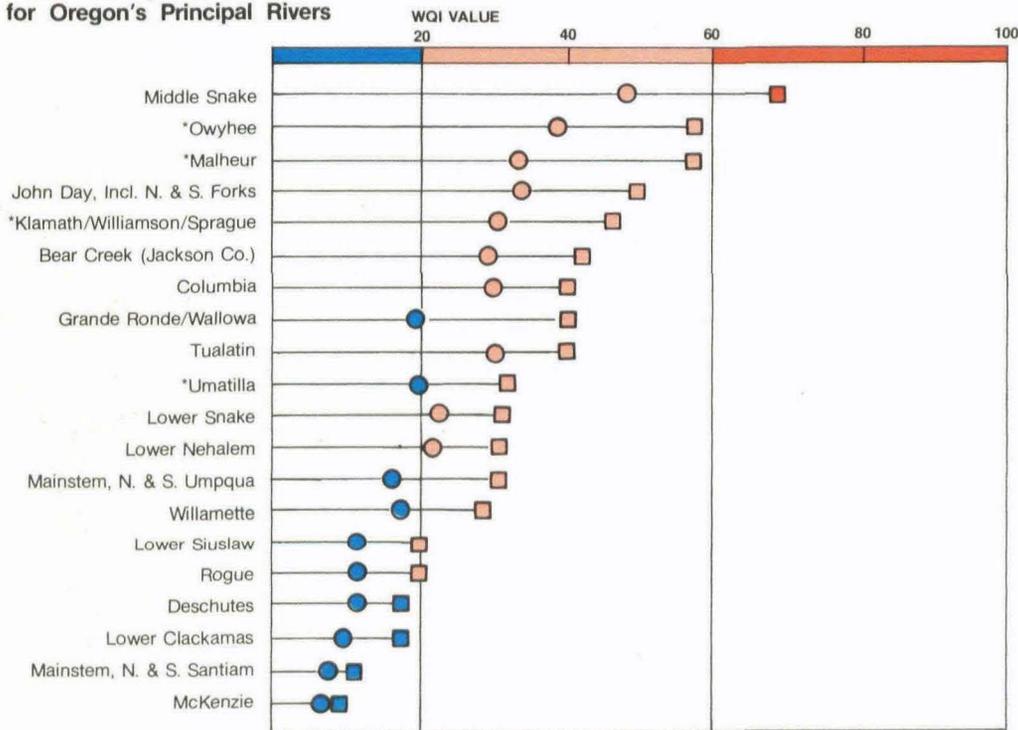
There is a significant lack of data on organic toxicants in Oregon streams, even though pesticides and herbicides are widely used in both agricultural and forestry activities throughout the state. Regular monitoring for a relatively small number of these chemicals has been performed in only a few of Oregon's streams in recent years. Except for the Klamath River, where concentrations of the pesticide Lindane were found in excess of the EPA criteria for aquatic life in 1976, this

limited monitoring program has not detected significant levels of organic toxicants to date. More widespread sampling for a much larger number of organic toxicants is being undertaken to better assess the extent of these compounds.

The inorganic toxicants category is primarily represented by the heavy metal parameters except for the South Umpqua, where only ammonia data is available. Seasonally low streamflows combined with sewage treatment plant effluent probably account for the elevated ammonia values. The highest levels of heavy metals occur in the Columbia River from unknown sources.

EPA stream monitoring for radiation in or near Oregon occurs quarterly on the Columbia River near Richland, Washington and Astoria, Oregon. Although there is insufficient criteria data available to calculate Index numbers for this category, observed radiation values at these sites are less than 5 percent of the EPA drinking water standard.

Figure 22.
Water Quality Index Values
for Oregon's Principal Rivers



The WQI values presented are derived from averaging WQI values from those river portions with adequate data. Except where indicated, river portions included are located only on the main river named.

*Portions of these streams were evaluated using criteria designed to protect warm water aquatic species, only.

- UNACCEPTABLE — SEVERE POLLUTION
- MARGINAL — INTERMITTENT, OR MODERATE POLLUTION
- ACCEPTABLE — MINIMAL, OR NO POLLUTION
- WORST 3 CONSECUTIVE MONTHS
- ANNUAL AVERAGE WATER QUALITY INDEX

River Water Quality Trends

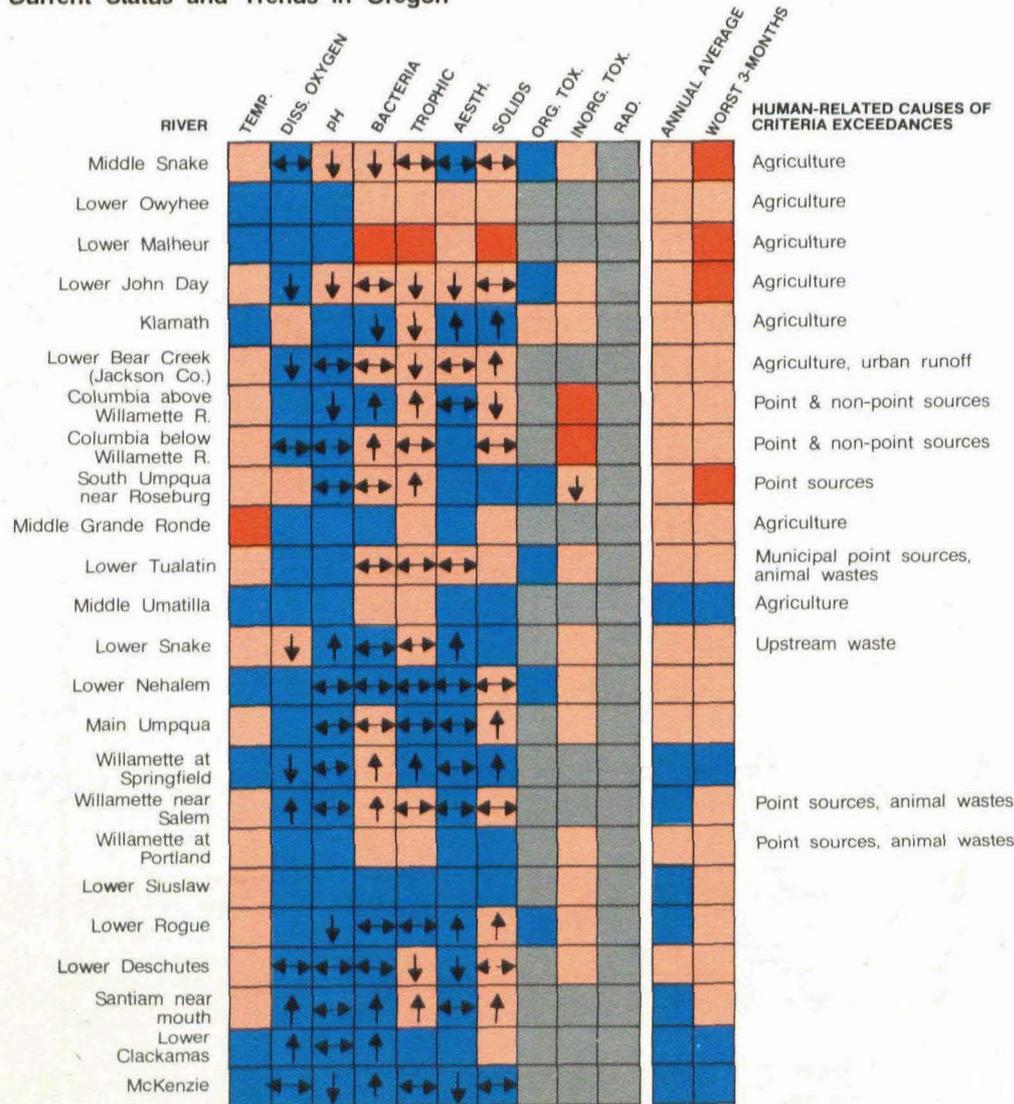
Figure 24 compares the year-to-year water quality at 22 monitoring stations within or bordering upon Oregon over the past 7 years. Although improvements due to point source controls have been documented, no significant improvement trends in statewide water quality are seen because of the influence of continuing natural and man-caused non-point source degradation at these stations.

Looking at the individual water quality categories and stream segments (Figure 24), it appears that conditions are deteriorating somewhat in several of the most degraded segments, while conditions in the Willamette River and its tributaries seem to be improving. The limited amount of data available for analysis makes it difficult to provide a more complete evaluation of Oregon water quality trends at this time.

The Outlook for Oregon

Many existing water quality problems in Oregon are due to non-point sources of pollution, especially agricultural sources. To address this problem, the Oregon Department of Environmental Quality (DEQ) has assessed the state's non-point source pollution and is now developing and beginning to apply best

Figure 23.
River Water Quality Categories
Current Status and Trends in Oregon



The colors depict the worst three-month status of each category during the water year 1978/1979 period. The arrows depict category trends as determined by a non-parametric statistical test of water year 1973 through 1979 data.

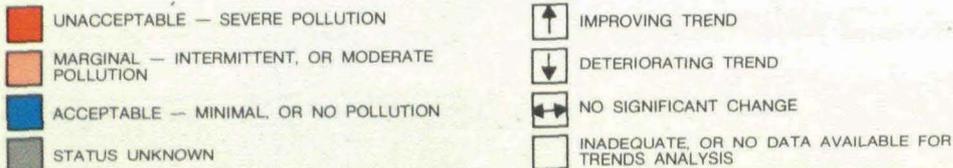
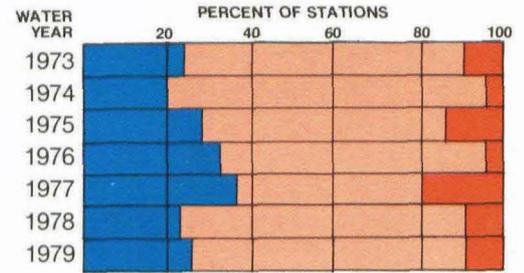


Figure 24.
Water Quality Trends in Oregon

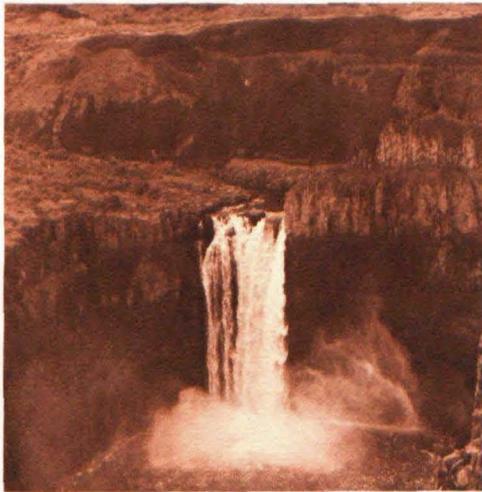


Based upon the water quality status during the worst 3 months at 22 monitoring stations within and bordering upon Oregon. Organic and inorganic toxicity parameter groups not included.

management practices to farms identified as pollution sources. DEQ works with agricultural agencies to encourage farmers to voluntarily use approved practices. Projects are underway that should reduce pollution levels in Bear Creek (Jackson County), the Owyhee and Malheur Rivers (Malheur County), the Umatilla River (Gilliam, Marion, Sherman, Umatilla, and Wasco Counties), and the Lower Columbia (Wasco County).

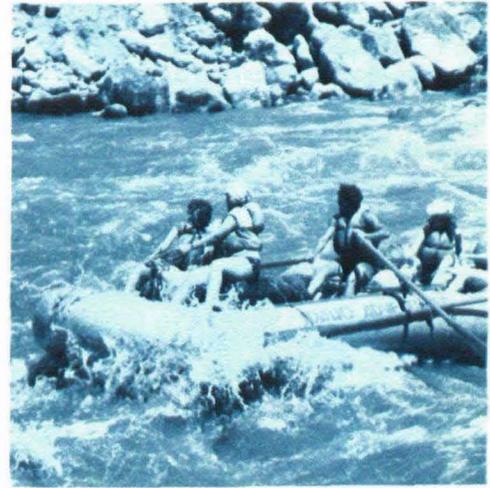
Forestry practices, which can also increase sediment and nutrient levels, are controlled in Oregon through the Forest Practices Act, which requires that road construction and logging activities minimize erosion and restricts logging adjacent to streams, thus protecting stream cover. The Act is enforced by officers who cite and fine contractors and private operations who fail to comply.

Control of point sources from industrial and sewage treatment operations through the NPDES permit system should improve water quality along specific stream segments. A regional treatment plant being constructed for the Eugene-Springfield area, for example, should significantly reduce bacterial levels in the Willamette River. Industries discharging to tributaries of the Willamette, such as the Teledyne Wah Chang plant at Albany, are reducing the levels of ammonia in their effluent. This should improve the level of dissolved oxygen in the river and reduce the toxicity and nutrient levels. Installation of secondary treatment facilities at several fruit processing plants has reduced the discharge of pollutants to the Columbia River.



sources, such as irrigation return flows, erosion from cultivated dryland areas, and runoff from grazing areas and feedlots.

Figure 27 shows the status of various segments of Washington's principal streams with respect to the 10 WQI categories. Summer stream temperatures exceed recommended criteria in the lower portions of many of the eastern Washington streams. As in Oregon, natural causes are probably the major contributors, but human activities compound the problem. Dissolved oxygen levels in the Spokane River immediately below Long Lake Dam fail to meet the minimum criteria during the late summer and fall. This condition is caused by the oxygen-consuming



The Quality of Washington's Principal Rivers

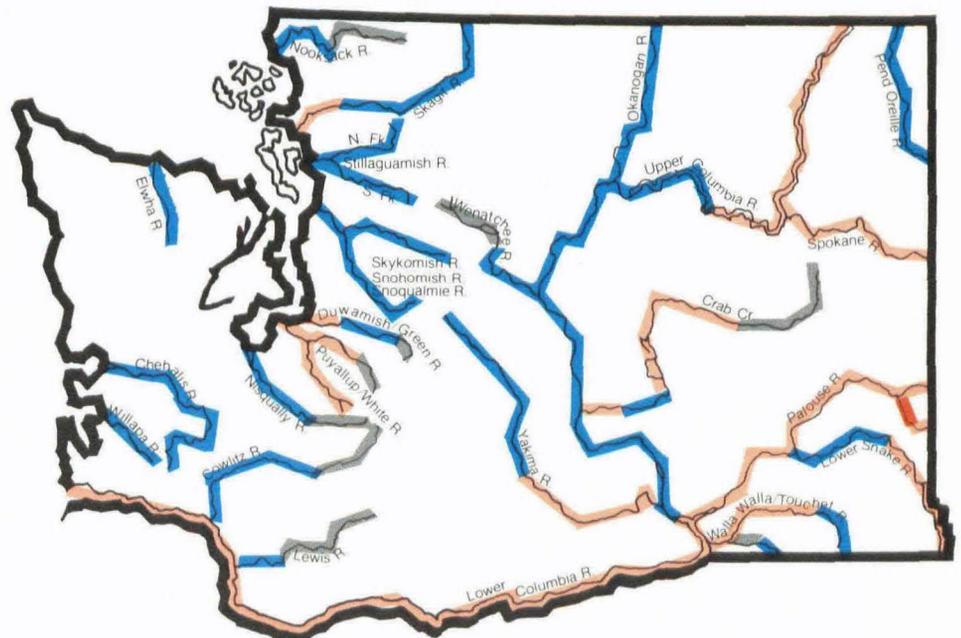
Figure 25 shows the location and extent of water quality within Washington's principal rivers and streams, and Figure 26 compares their water quality in WQI terms.

On an average annual basis, the majority of streams generally meet the Federal water quality goals. The South Fork of the Palouse currently appears to be the most degraded Washington stream and does not meet Federal goals. During their worst 3-month conditions, over half of the streams may be considered marginal with respect to the goals.

The marginal rating for the Puyallup/White system and the Upper Nisqually is primarily due to criteria exceeded in the aesthetics and solids categories, caused by glacial meltwater. In the Lower Columbia, this rating is due to elevated heavy metals levels from unknown sources.

Many of the state's water quality problems are found in the lower portions of the Yakima, Crab Creek, Walla Walla/Touchet, and Palouse drainages, where the effects of climatically induced low streamflows and high summer temperatures are aggravated by man's activities. Problems typically encountered include high levels of bacteria, turbidity, suspended solids, and nutrients, as well as elevated summer water temperatures. Most of these problems are attributed to agricultural and livestock-related non-point

Figure 25. Water Quality Status of Washington's Principal Rivers



BASED UPON THE AVERAGE ANNUAL WQI:

- UNACCEPTABLE — SEVERE POLLUTION
- MARGINAL — INTERMITTENT, OR MODERATE POLLUTION
- ACCEPTABLE — MINIMAL, OR NO POLLUTION
- STATUS UNKNOWN

decay of algae and other organic material within Long Lake, which are either contributed to or stimulated by upstream sources. Excessive bacterial levels are mostly found in the lower portions of eastern Washington's streams, with irrigation, precipitation, and snowmelt runoff from grazing and animal confinement areas the probable causes. However, sewage treatment

wastes may be primarily responsible for exceedances in the South Fork Palouse and Duwamish Rivers.

The most severe exceedances of the aesthetics and solids criteria generally occur in the more intensely farmed areas of southern and eastern Washington, particularly during periods of rainfall and snowmelt runoff.

Recent monitoring of the lower Spokane, Elwha, and Yakima Rivers for organic toxicants indicates no significant levels of these compounds. More widespread sampling for a much larger number of organic toxicants is being undertaken to better assess their extent in Washington's streams.

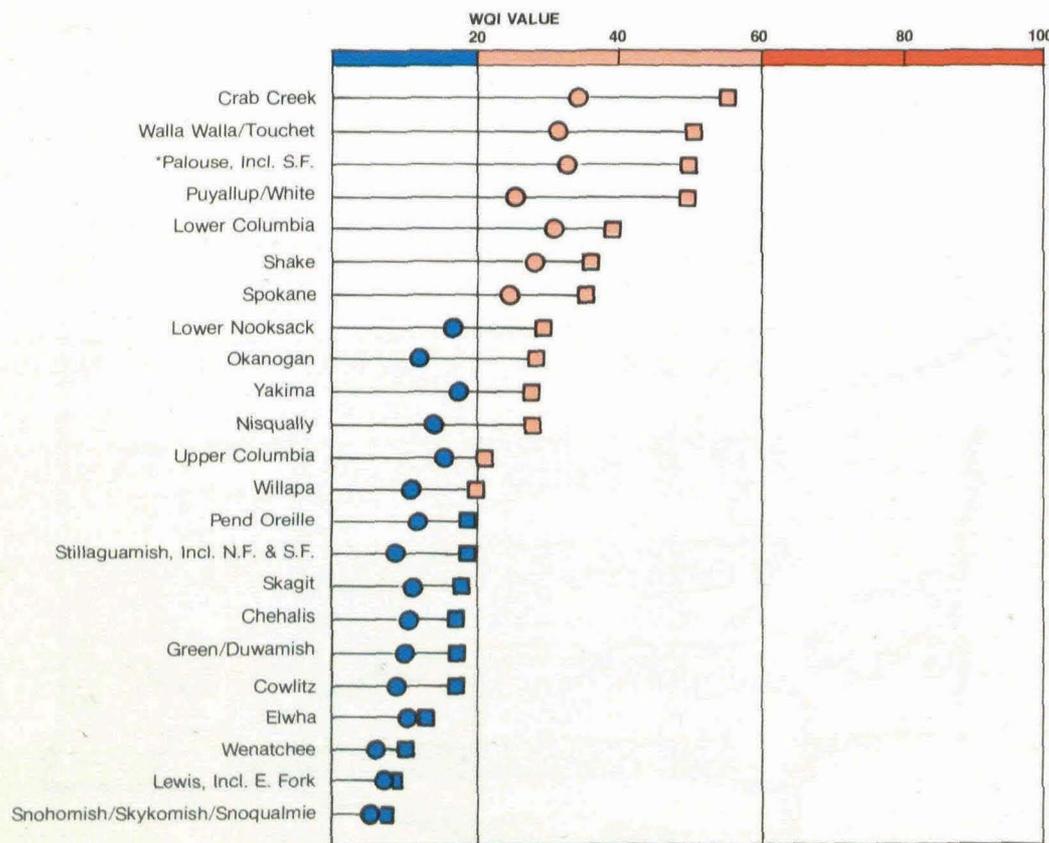
Inorganic toxicants include the heavy metals zinc, lead, and cadmium, which can harm fish and persons who eat contaminated fish. A number of Washington rivers appear not to meet recently refined Federal criteria. However, for most of these streams, it is not clear at this time whether there is a genuine problem with inorganic toxicants or simply a problem with insufficiently sensitive analytical and monitoring techniques. Past and present mining and smelting activities in Idaho's South Fork Coeur d'Alene River drainage are responsible for excessive inorganic toxicant levels in the Spokane River.

EPA stream monitoring for radiation in or near Washington occurs quarterly on the Columbia River near the Canadian border, Richland, and Astoria, Oregon. Although insufficient criteria data is available to calculate Index numbers for this category, observed radiation values at these sites are less than 3 percent of the EPA drinking water standard.

River Water Quality Trends

Figure 28 compares the year-to-year water quality at 39 monitoring stations within, or bordering upon, the state over the past 7 years. As in Oregon, improvements due to point source controls have been documented. No significant improving trends in the overall water quality status are seen, however, due to the influence of continuing natural and human related non-point source degradation at these stations. Incomplete data from some of the monitoring stations and variations in the climate and sampling times combine to add difficulties to the attempt to analyze water quality trends.

Figure 26.
Water Quality Index Values
for Washington's Principal Rivers

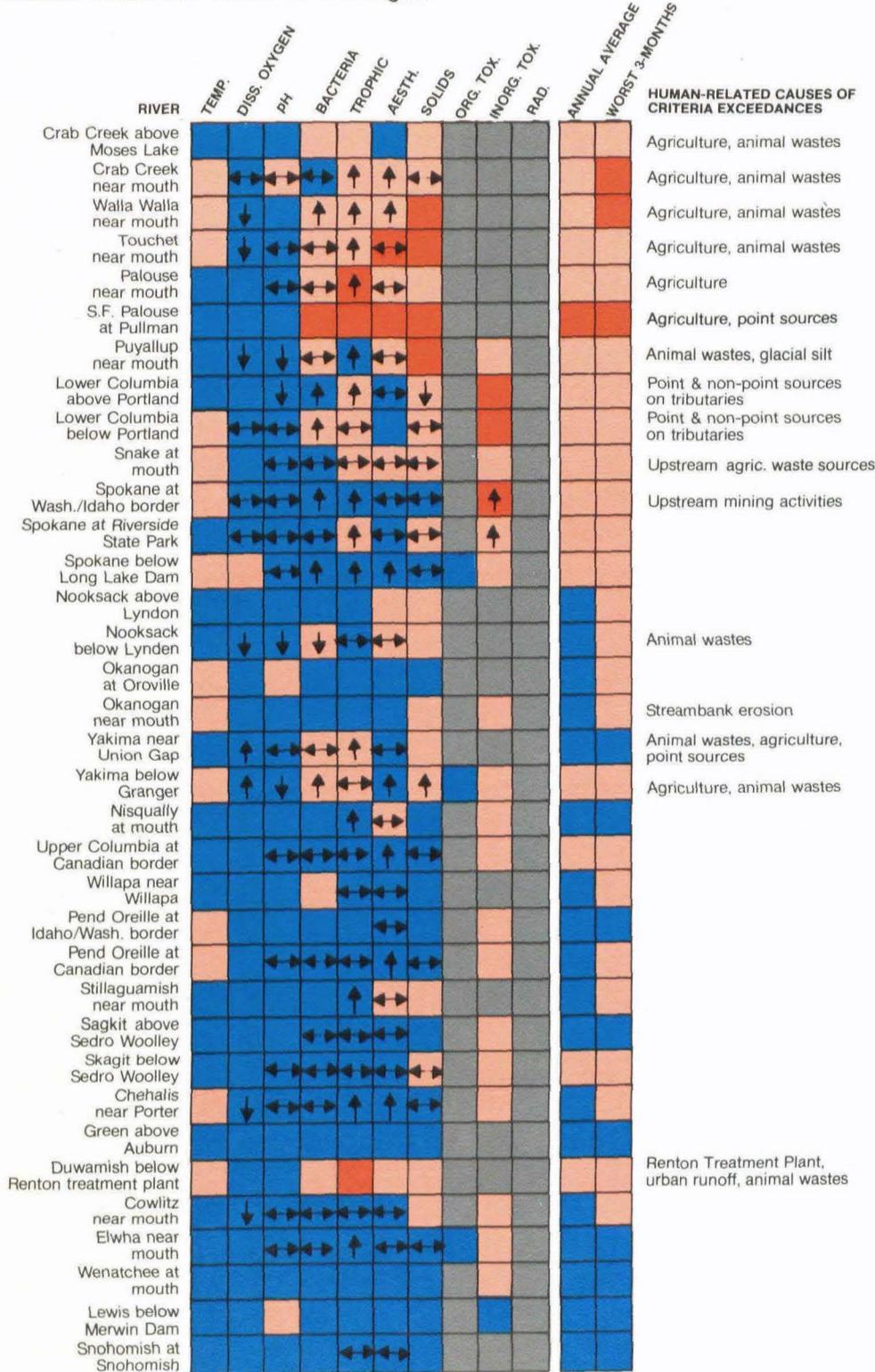


- UNACCEPTABLE — SEVERE POLLUTION
- MARGINAL — INTERMITTENT, OR MODERATE POLLUTION
- ACCEPTABLE — MINIMAL, OR NO POLLUTION
- WORST 3 CONSECUTIVE MONTHS
- ANNUAL AVERAGE WATER QUALITY INDEX

The WQI values presented are derived from averaging WQI values from those river portions with adequate data. Except where indicated, river portions included are located only on the main river named.

*Evaluated using criteria designed to protect warm water aquatic species only.

Figure 27.
River Water Quality Categories
Current Status and Trends in Washington

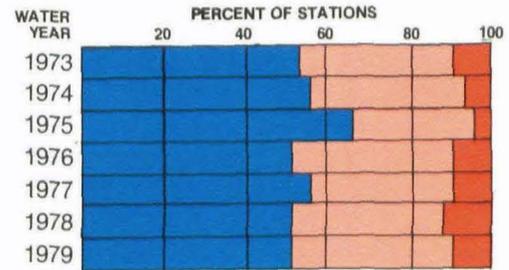


UNACCEPTABLE — SEVERE POLLUTION
 MARGINAL — INTERMITTENT, OR MODERATE POLLUTION
 ACCEPTABLE — MINIMAL, OR NO POLLUTION
 STATUS UNKNOWN
 INADEQUATE, OR NO DATA AVAILABLE FOR TRENDS ANALYSIS

IMPROVING TREND
 DETERIORATING TREND
 NO SIGNIFICANT CHANGE

The colors depict the worst three-month status of each category during the water year 1978/1979 period. The arrows depict category trends as determined by a non-parametric statistical test of water year 1973 through 1979 data.

Figure 28
Water Quality Trends in Washington



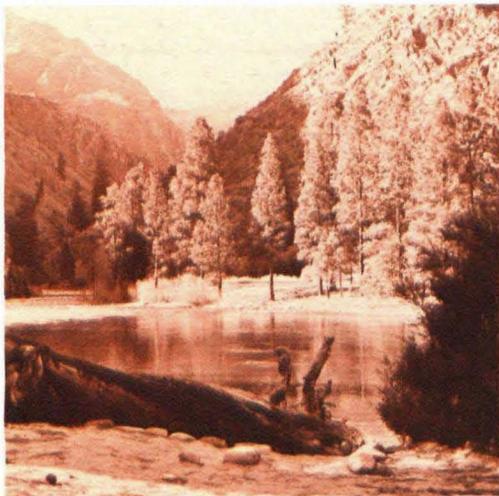
Data based upon the worst 3 consecutive months status of 39 monitoring stations within, and bordering upon, Washington. Organic and inorganic toxicant categories not included.

Figure 27 indicates some improvement in certain categories in the most-degraded stream segments in eastern Washington, particularly with respect to trophic conditions. In fact, where data is available, it appears that nutrient levels are declining in many stream segments across the state. Because limited data is available for trends analysis, it is difficult to more completely evaluate water quality trends within the state at this time.

The Outlook for Washington

The NPDES permit system and implementation of areawide wastewater management plans being developed should correct many of the pollution problems discussed above. New and improved sewage treatment plants, improved operation of existing plants, and best management practices in agricultural and livestock operations should most noticeably improve bacteria, nutrients, and solids levels. The effect of forest practices on erosion and temperature levels is being controlled through the Forest Practices Act.

Programs are underway to determine the extent of organic toxicants. If significant levels are found, they are likely to be in metropolitan areas where the impact of both municipal and industrial waste discharges are the greatest. Elevated levels may also be found in streams that drain agricultural areas with high pesticide usage.



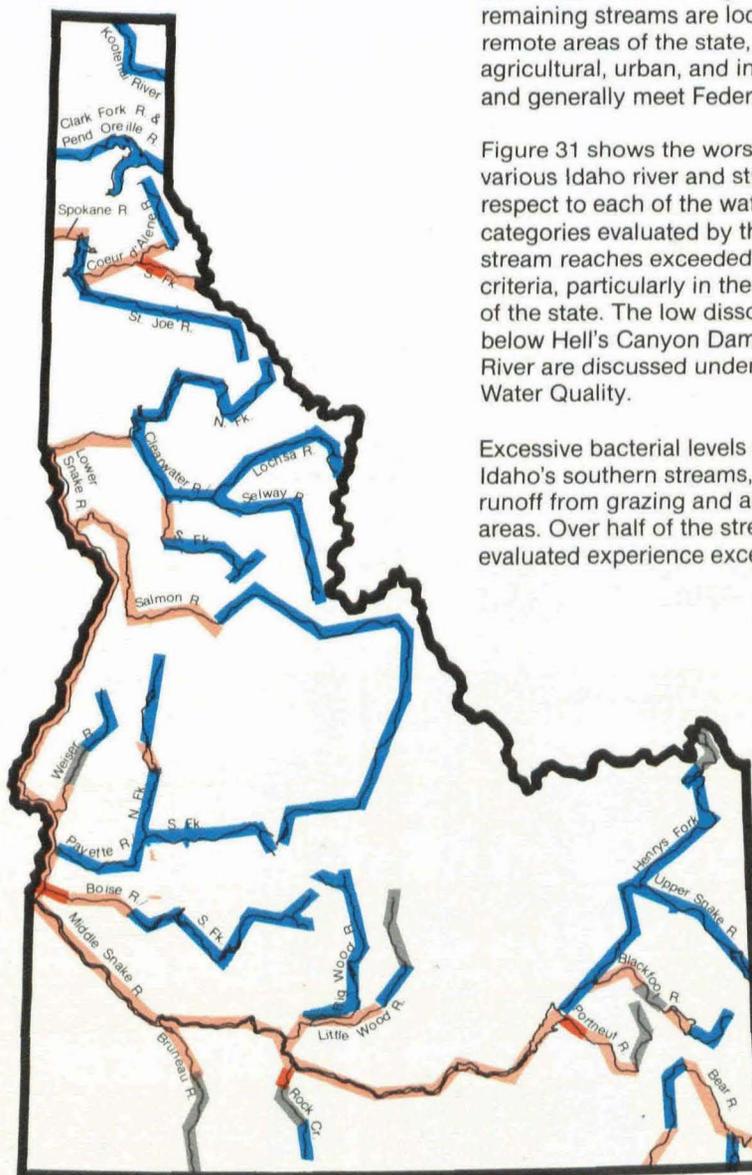
The Quality of Idaho's Principal Rivers

Figure 29 shows the location of the major Idaho streams and the general extent of water quality degradation within their reaches based upon the average annual WQI. Figure 30 compares their average annual and worst 3-month WQI values.

Much of the South Fork Coeur d'Alene River is affected by wastes from past and present mining and ore-producing activities within its basin. Pollution from these activities also causes the Spokane and main Coeur d'Alene Rivers to be rated marginal. The lower Portneuf River has been degraded by a combination of municipal, industrial, agricultural, and natural sources. Since the summer of 1980, however, much of the municipal and industrial wastewater has been diverted from the river. Rock Creek, which flows through Twin Falls, is heavily impacted by irrigation wastewater entering its lower reaches.

Most of the other principal streams monitored in Idaho only marginally meet Federal water quality goals during their worst 3-month periods; many of their problems are attributed to agricultural non-point sources, particularly in Southern Idaho. Some stream reaches are affected by point source discharges from sewage treatment and industrial plants, for example, the Boise River and Milner Reservoir, located

Figure 29.
Water Quality Status of Idaho's Principal Rivers



BASED UPON THE AVERAGE ANNUAL WQI:

- UNACCEPTABLE — SEVERE POLLUTION
- MARGINAL — INTERMITTENT, OR MODERATE POLLUTION
- ACCEPTABLE — MINIMAL, OR NO POLLUTION
- STATUS UNKNOWN

on the Snake River. High heavy metals levels from unknown sources are primarily responsible for the Lower Salmon and Clearwater Rivers' marginal ratings. The remaining streams are located in more remote areas of the state, lack significant agricultural, urban, and industrial activities, and generally meet Federal goals.

Figure 31 shows the worst 3-month status of various Idaho river and stream reaches with respect to each of the water quality categories evaluated by the WQI. Many stream reaches exceeded the temperature criteria, particularly in the more arid portions of the state. The low dissolved oxygen levels below Hell's Canyon Dam on the Snake River are discussed under Oregon River Water Quality.

Excessive bacterial levels occur in some of Idaho's southern streams, due primarily to runoff from grazing and animal confinement areas. Over half of the stream segments evaluated experience excessive levels of

nutrients (trophic category) during at least part of the year. These are mostly over-enriched by runoff from irrigated and dryland agriculture, although secondary treated sewage may be contributing to these problems in some streams, such as the Boise River.

The highest suspended solids levels observed in the state were found in the lower portions of Rock Creek, Bruneau River, Portneuf River, and in the Bear River near the Wyoming border. Irrigation return flows are mostly responsible for these levels in Rock Creek, while rainfall and snowmelt runoff from dryland agricultural areas account for the high solids levels in the other three streams.

Limited monitoring for organic toxicants in the water on the Snake, Bear, Kootenai, and Salmon Rivers has not revealed significant levels of contamination in recent years. Fish tissue samples taken at 19 trend stations in Idaho indicated that no criteria levels were exceeded for 22 pesticides and other organics. However, 26 percent and 30 percent of the total DDT and PCB samples, respectively, exceeded recommended concentrations for the protection of fish-eating birds and mammals. Large amounts of PCB's were released to the Upper Snake River following the flooding caused by the failure of the Teton Dam.

High levels of heavy metals from the aforementioned mining and smelting

sources are causing criteria exceedances in parts of the Spokane/Coeur d'Alene River system.

Insufficient criteria exist to allow formulation of Index numbers for the radiation category. Compared to the Idaho regulations for public drinking water systems, however, recent data shows that a few stream segments exceeded these criteria. These are believed to be caused by naturally occurring uranium in the soils.

River Water Quality Trends

The general water quality picture in Idaho, as represented by the 28 monitoring stations evaluated in Figure 32, has exhibited little apparent change over the past 7 years for the same reasons explained in the Oregon and Washington discussions.

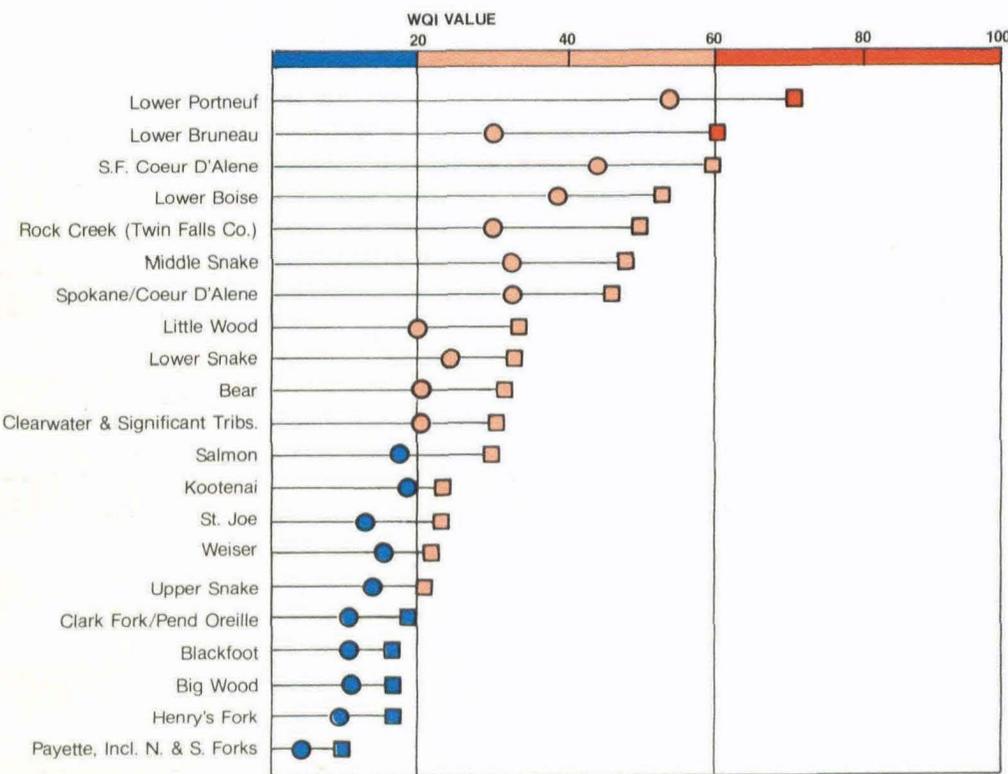
Trends within individual categories (Figure 31) indicate improvement in the aesthetics and solids categories in many of the stream segments. Segments exhibiting improvements in the greatest number of categories are the Kootenai River near the Canadian border and the Snake River near Mountain Home.

The Outlook for Idaho

Reductions in point source pollution in Idaho are being achieved by means of NPDES permits and earlier cooperative state, industry, and municipal efforts. Problems still exist, however, with sewage treatment, including inadequate treatment levels, overloading of facilities from infiltration/inflow, and insufficient dilution of sewage effluent due to low streamflows. Food processing industries and mining and ore processing facilities are other major point sources requiring improvements.

Agriculture continues to be one of the most significant non-point sources of water pollution in Idaho. A Statewide Agricultural

Figure 30.
Water Quality Index Values
for Idaho's Principal Rivers

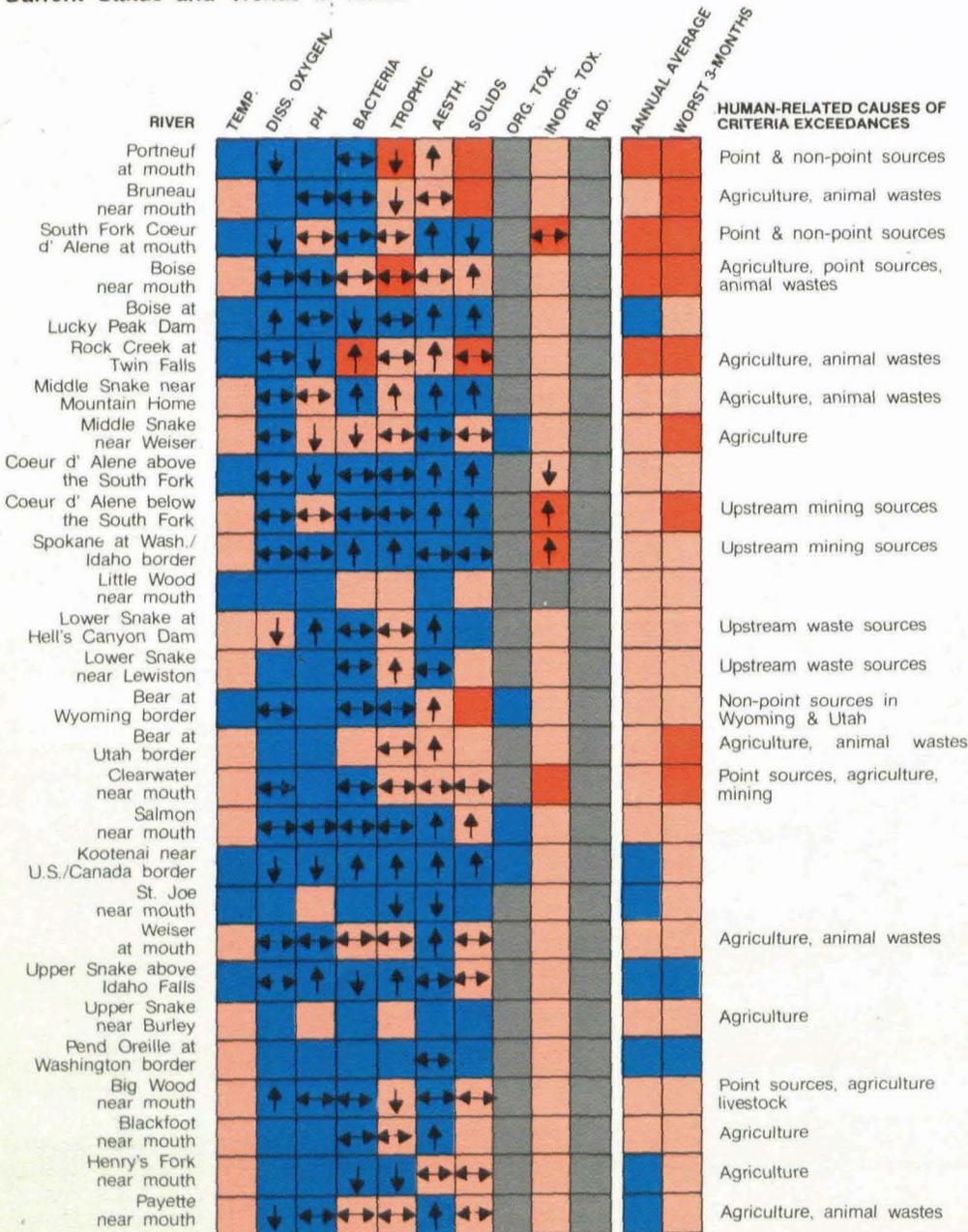


The WQI values presented are derived from averaging WQI values from those river portions with adequate data. Except where indicated, river portions included are located only on the main river named.

□ WORST 3 CONSECUTIVE MONTHS
○ ANNUAL AVERAGE WATER QUALITY INDEX

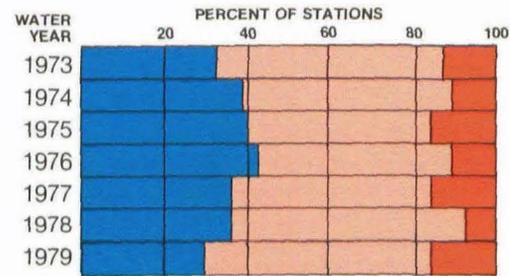
UNACCEPTABLE — SEVERE POLLUTION
MARGINAL — INTERMITTENT, OR MODERATE POLLUTION
ACCEPTABLE — MINIMAL, OR NO POLLUTION

Figure 31.
River Water Quality Categories
Current Status and Trends in Idaho

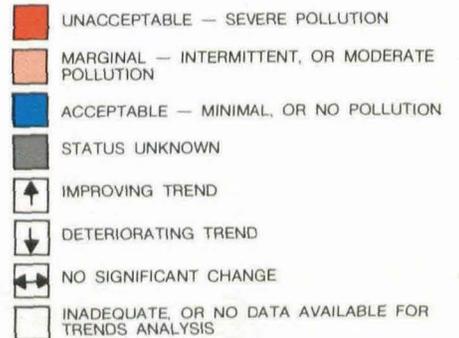


The colors depict the worst three-month status of each category during the water year 1978/1979 period. The arrows depict category trends as determined by a non-parametric statistical test of water year 1973 through 1979 data.

Figure 32.
Water Quality Trends in Idaho



Based upon the water quality status during the worst 3 months at 28 monitoring stations within and bordering upon Idaho. Organic and inorganic toxicity parameter groups not included.



Pollution Abatement Plan was completed in 1979. This voluntary program is being implemented on a statewide basis, and specifically using 208 projects in four high-priority areas: Rock Creek and Cedar Draw in Twin Falls County, Paradise Creek-South Fork Palouse River in Latah County, and Marsh Creek in Bannock County.

Mining activities are another major non-point source of pollution. Significant improvement in water quality would result if discharges from the Bunker Hill Company in Kellogg were to meet EPA guidelines; however, runoff from abandoned and inactive mining operations, which is difficult and expensive to control, would still create problems in the South Fork and main Coeur d'Alene Rivers. State plans to rehabilitate the South Fork have been hampered by lack of funds.

Figure 33.
Water Quality Status of Alaska's
Principal Rivers

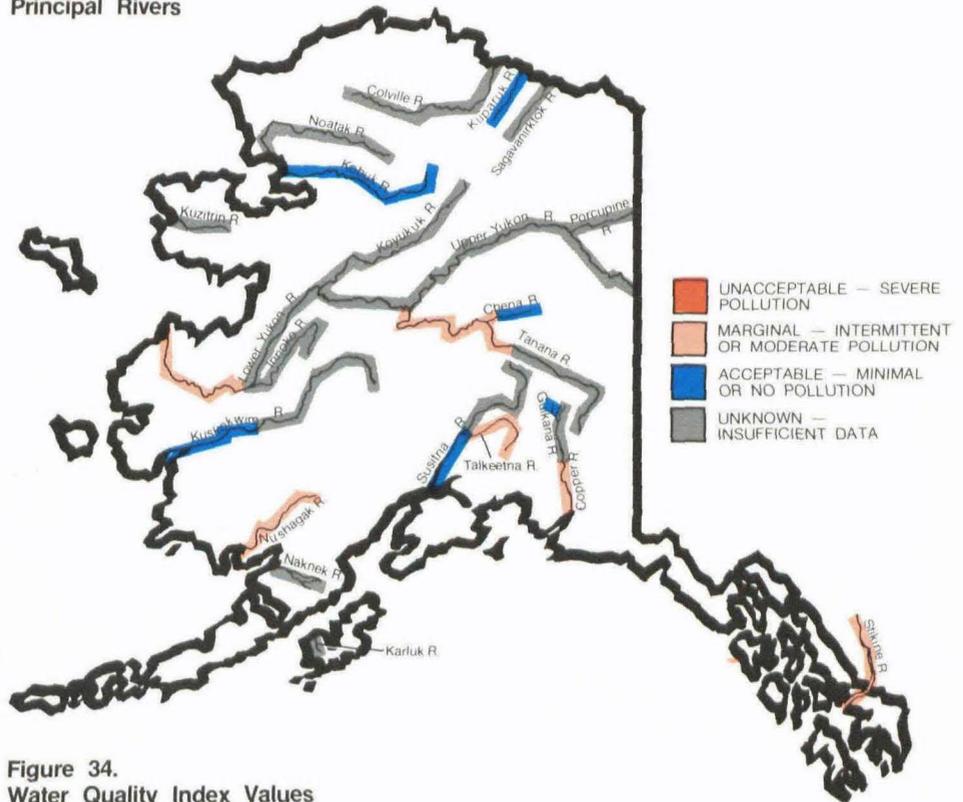
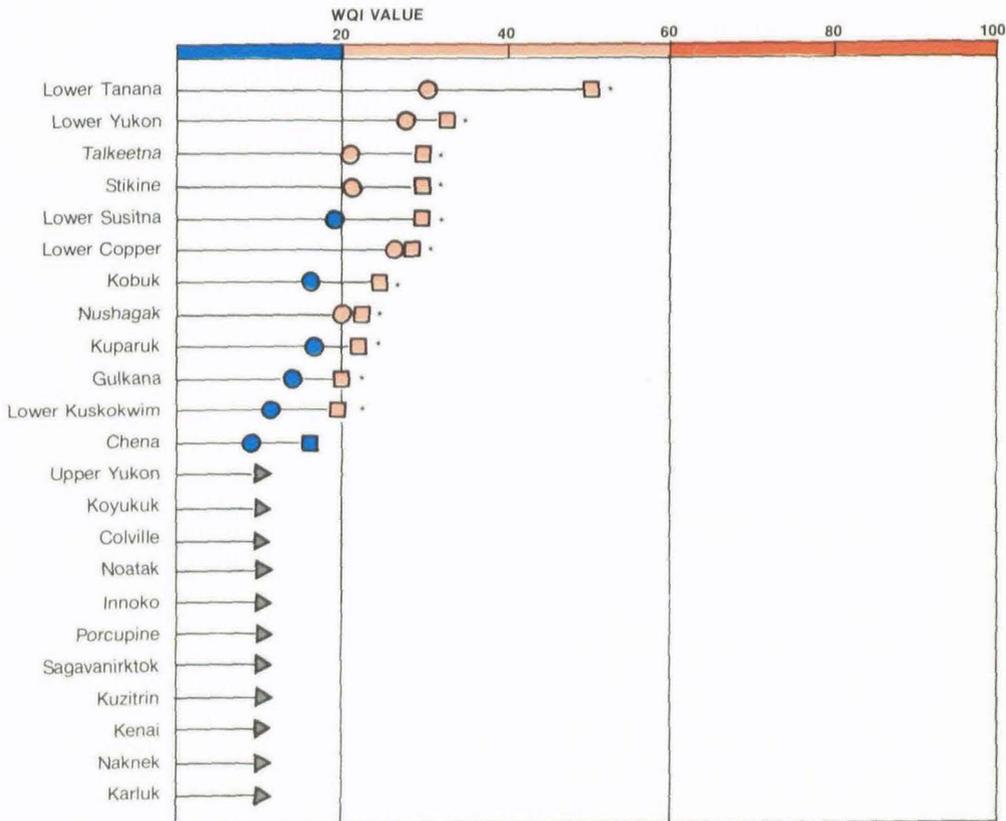


Figure 34.
Water Quality Index Values
for Alaska's Principal Rivers



*All marginal rivers exceed sediment criteria which may be due to natural causes, such as glacial flows.

NOTE: Due to insufficient data, index numbers could not be calculated for some rivers. Those values presented are calculated from only one monitoring station on each river.

- WORST 3 CONSECUTIVE MONTHS
- ANNUAL AVERAGE WATER QUALITY INDEX
- ▷ INSUFFICIENT DATA



The Quality of Alaska's Principal Rivers

Because most of Alaska is remote and inaccessible, water quality information is scattered, as well as difficult and expensive to obtain; therefore half of the state's principal streams cannot be evaluated. Available data from October 1977 through September 1979 were used to indicate the general status of the principal Alaska rivers. Where insufficient data existed for that period, data from October 1972 through September 1979 were used. Figure 33 shows the location and water quality status of these streams, and Figure 34 compares the Index values from the single stations that represent each river.

None of the rivers with data appear to be severely degraded. River segments rated marginal are primarily exceeding turbidity (aesthetics), suspended solids, and heavy metals (inorganic toxicants) criteria on an intermittent basis. The high levels of the first two are primarily due to natural occurrences, such as ice breakup and runoff from the snowpack and glaciers. Human activities, such as placer mining and construction, may be partially responsible, particularly in some of the smaller tributary streams. Metals criteria exceedances may be due to a combination of factors, such as mining activities, natural geological processes, and the criteria/reporting problem discussed earlier.

Figure 35.
River Water Quality Categories
Current Status in Alaska

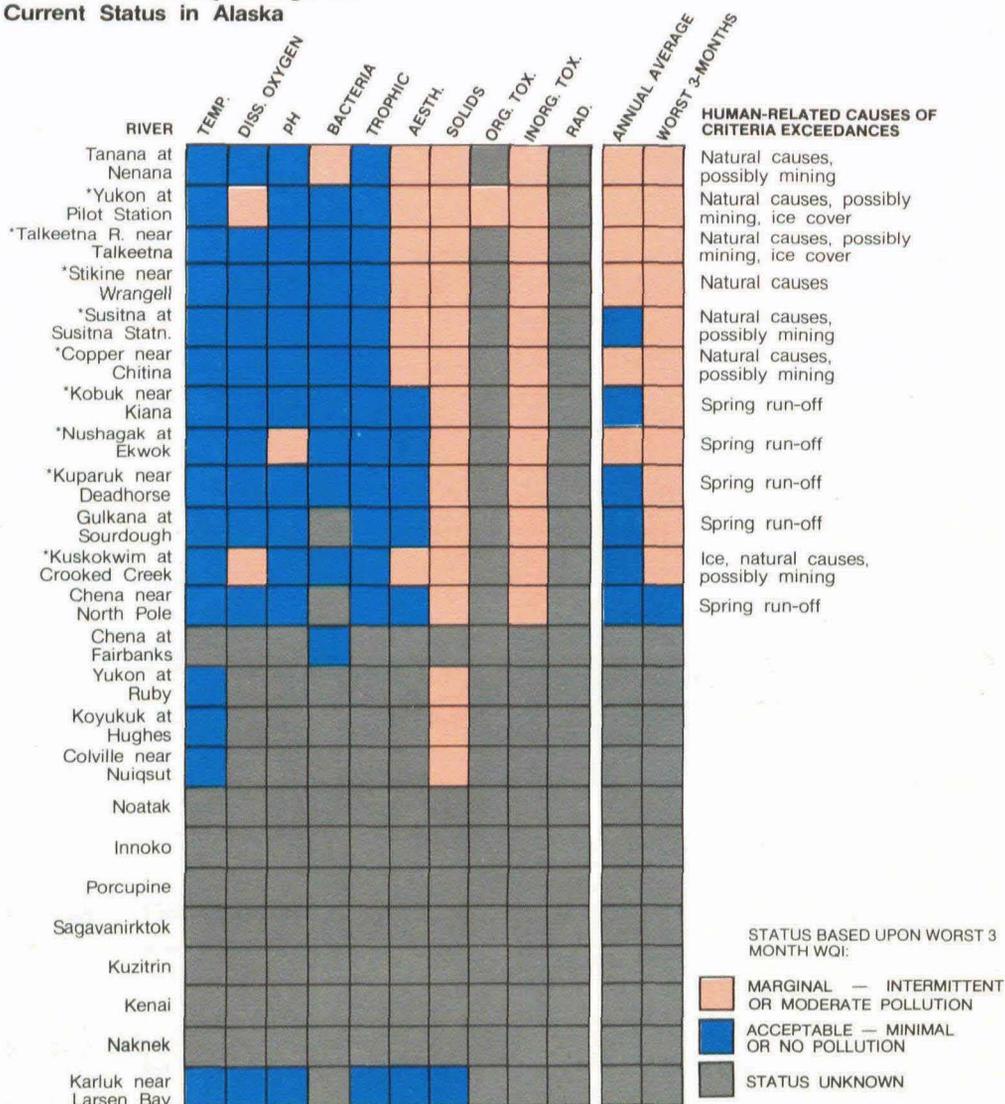


Figure 35 shows the current status of river water quality categories in Alaska. The bacterial problem indicated in the Tanana River is based upon 1973 and 1974 data and was due to sewage discharges from the Fairbanks area into the Chena River, a tributary to the Tanana. Since late 1976, these wastes have been diverted from the Chena River and treated by a new sewage treatment plant, which discharges to the Tanana River. Recent data indicate that the Chena at Fairbanks, once severely polluted by these discharges, now has acceptable bacterial levels. This will improve water quality in the Tanana, although no post-treatment data are available at this time.

Low dissolved oxygen levels in the Yukon and Kuskokwim River segments occur in the winter months due to the ice cover. Low pH values are occasionally observed in the Nushagak River for unknown reasons. The marginal organic toxic rating for the Yukon River is due to one 2,4-D sample in excess of the criteria.

The Outlook for Alaska

The challenge for the future in Alaska will be to preserve the high level of environmental quality. Greater use of the vast natural resources of the state and increased population could result in significant deterioration of water quality.

Alaska's wastewater treatment program for municipal and industrial discharges is well-advanced but not yet complete; therefore continued emphasis on this program will be necessary to maintain water quality. Untreated domestic sewage discharges have been reduced in areas such as the Chena River near Fairbanks; however, many other interior and coastal communities still have inadequate sewage treatment facilities. Pulp mills are presently increasing their treatment levels. As additional industrial treatment needs are met, water quality in localized areas should improve.

Urban center growth, resulting in increased discharges and urban runoff as well as increased recreational pressures on lakes and streams, will continue to cause problems in large communities such as Anchorage, Fairbanks, and Juneau. Various state and

local management agencies are presently identifying urban problems and developing prevention programs.

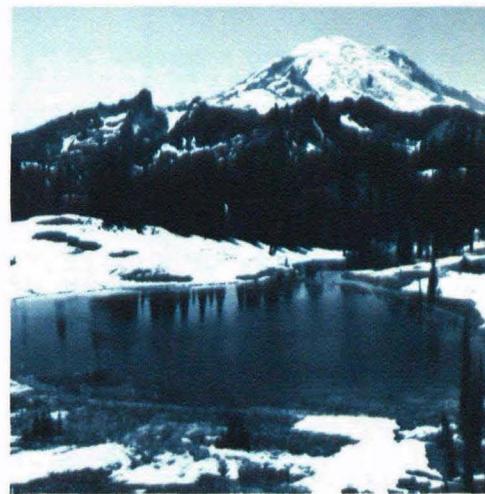
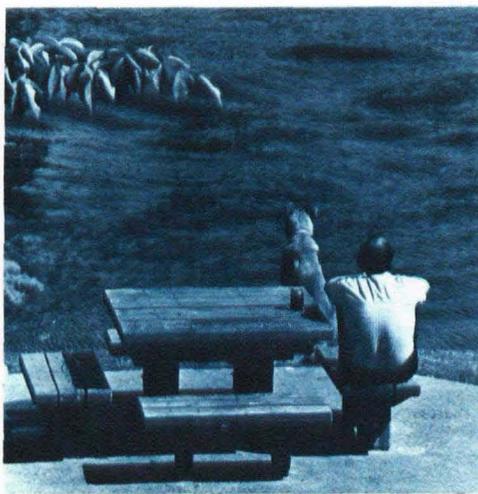
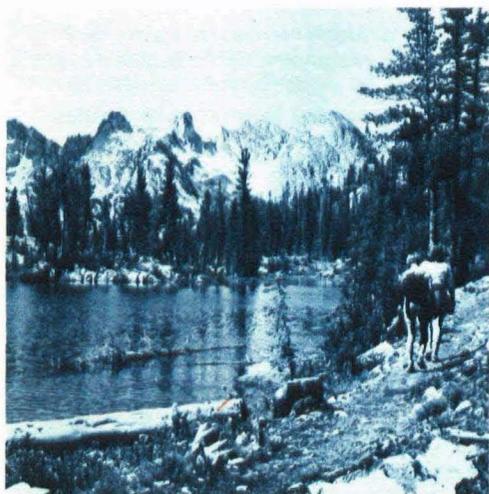
Water quality degradation resulting from placer mining activities will be difficult to control. Because of the remoteness of these areas, technical evaluation of mining effects and control programs have not advanced. It is doubtful that mitigation of the effects of placer mining will be possible in the next few years.

Timber harvesting as a non-point pollution source will become more significant in the future. Logging and the road construction that accompanies it add to the sediment load in a stream through accelerated erosion, particularly if the streambank vegetation is removed in the process. In the past, Alaska's timber industry existed on publicly owned

timber land. Timber harvesting practices were rigidly established in lease and contract stipulations, although contract enforcement was frequently deficient. Such Federal controls would not apply to the millions of acres of land being conveyed into state and private ownership as a result of the Statehood Act, Alaska Native Claims Act, and state land disposal programs.

Construction in general, especially for roads, railroads, and pipelines also causes increased erosion and sediment loads. Conditions unique to Alaska, including permafrost, unstable stream channels, extreme temperature ranges, and glacial action accentuate the problem. Many of these situations are still being studied. The state is developing a manual of best management practices for transportation corridors.

Lake Water Quality



Inland lakes and waterways constitute one of the Region's most important recreational and commercial resources. It is generally felt that the lake water quality in the Pacific Northwest is among the best in the Nation. Only a few of the major recreational lakes have significant water quality problems that impair their recreational use.

How Lake Water Quality is Determined

A numerical water quality index has not been developed for lakes, as it has been for rivers. Instead, the water quality of the Region's lakes is evaluated based on ecological conditions (trophic status) and their impact on recreational use of the lakes. For comparison purposes, and to help analyze the extent to which recreational uses are impaired in any given lake, the measurement criteria shown in Table 3 were applied.

Factors Affecting Recreational Uses of Lakes

If a lake is undisturbed by human activities, it undergoes a natural process of aging known as eutrophication. Man's activities, however, may accelerate this process by introducing nutrients to lake waters through improper land use and waste disposal practices. Land use practices on farm land, forests, and construction sites often result in erosion of nutrient-rich soils into streams feeding lakes. Significant quantities of nutrients are also discharged by sewage treatment and certain industrial plants and urban, pasture, and feedlot runoff.

Water quality agencies are concerned with the trophic status of the Region's lakes because their many uses depend on their ecological conditions. Highly eutrophic lakes are characterized by dense algal blooms, floating mats of vegetation, and a murky appearance. Algae are found naturally in every body of

water, but when stimulated by abundant nutrients, sunlight, and warm temperatures, they rapidly multiply to become a nuisance to recreational users while seriously affecting water quality for other uses. These plant nuisances may curtail or even eliminate recreational activities (such as swimming, boating, and fishing), impart tastes and odors to water supplies, and cause toxic conditions which adversely affect other aquatic life in the lakes. For example, when sufficient quantities of these growths die, the decaying process may consume quantities of dissolved oxygen sufficient to kill fish and other aquatic life. The recreational use of lakes in itself can affect water quality. Power boats create waves that erode banks, contributing to sediment, nutrients, and muddy water; they also release mixtures of oil and gasoline and associated contaminants to the water. Removal of vegetation along shorelines to enhance public access can also lead to erosion.

Table 3.
Criteria for Evaluating Impairment of Lakes

| RECREATIONAL USE | DEGREE OF IMPAIRMENT | |
|------------------|--|-------------|
| | CRITERIA | SCORE |
| | NONE | |
| Swimming | Very low bacteria levels (Fecal coliforms geometric mean less than 50 per 100 ml) | 1 |
| Fishing | No adverse conditions. Healthy fish population. | 1 |
| Boating | Less than 10% of surface area affected by aquatic weeds | 1 |
| Aesthetics | Objects visible in water to depth of 10 feet or more and low phosphorus (Secchi Disc* at 10 feet; total phosphorus of less than 10 ug/l**) | 1 |
| SCORE | (No uses impaired) | 4 |
| | MODERATE | |
| Swimming | Moderate bacteria levels (Fecal coliforms 50 to 200 per 100 ml). | 2 |
| Fishing | Slightly adverse conditions. Slight reduction in fish population. | 2 |
| Boating | 10% to 30% affected | 2 |
| Aesthetics | Objects visible from 1.5 to 10 feet and moderate phosphorus level (Secchi Disc at 1.5 to 10 feet; total phosphorus 10 to 20 ug/l) | 2 |
| SCORE | (All uses moderately impaired) | 5-8 |
| | SIGNIFICANT | |
| Swimming | Unhealthy bacteria levels (Fecal coliforms greater than 200 per 100 ml) | 3 |
| Fishing | Adverse conditions. Significant reduction in fish population. | 3 |
| Boating | More than 30% affected | 3 |
| Aesthetics | Objects not visible beyond 1.5 feet or high phosphorus level (Secchi Disc at less than 1.5 feet; total phosphorus greater than 20 ug/l) | 3 |
| SCORE | (All uses significantly impaired) | 9-12 |

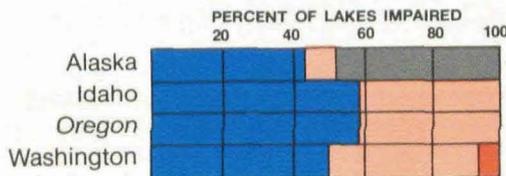
The Regional Overview

The principal recreational lakes within the Region are of good quality, with relatively few impairments related to human activities. Figure 36 compares the percentage of lakes impaired for recreational use in each state. Figure 37 shows the location and impairment status of each lake on regional maps. Approximately half of the lakes assessed in Oregon, Washington, and Idaho, and most of the Alaskan lakes for which there is information, have little or no recreational impairment. However, some of these lakes are approaching a level of eutrophication that interferes with their desired uses.

The EPA Clean Lakes Program provides Federal grants to state water quality agencies to improve lake quality. In Washington, this

program is supplemented by a state lake restoration program which provides matching funds to local agencies. Some measures being implemented to improve lake water quality include dredging to remove nutrient-containing sediments and decomposing plant material that consumes oxygen, flushing, bank erosion control, aeration, physically removing aquatic plants, and both chemical and biological controls to prevent eutrophication. Through these programs, many of the high-use recreational lakes in the Region are being restored and preserved for future generations.

Figure 36.
Impairment Status of Recreational Lakes in Region 10



Based upon evaluation of 145 Region 10 lakes

- LITTLE OR NO IMPAIRMENT
- MODERATE IMPAIRMENT
- SIGNIFICANT IMPAIRMENT
- STATUS UNKNOWN

*A Secchi Disc is a round black and white plate suspended on a chain and used to determine water clarity.

**ug/l = micrograms per liter, a measurement used for low concentrations of dissolved substances.

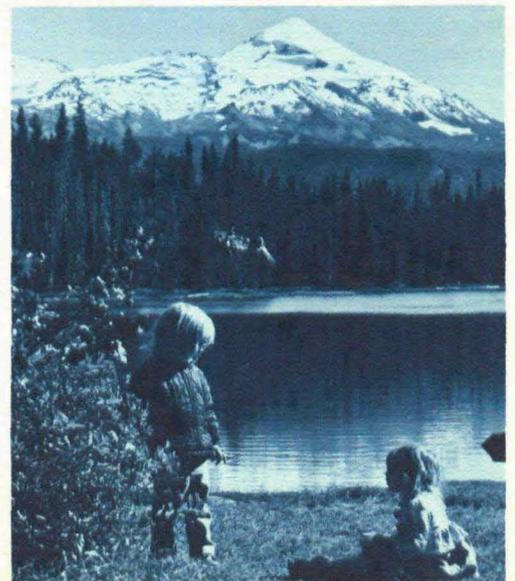
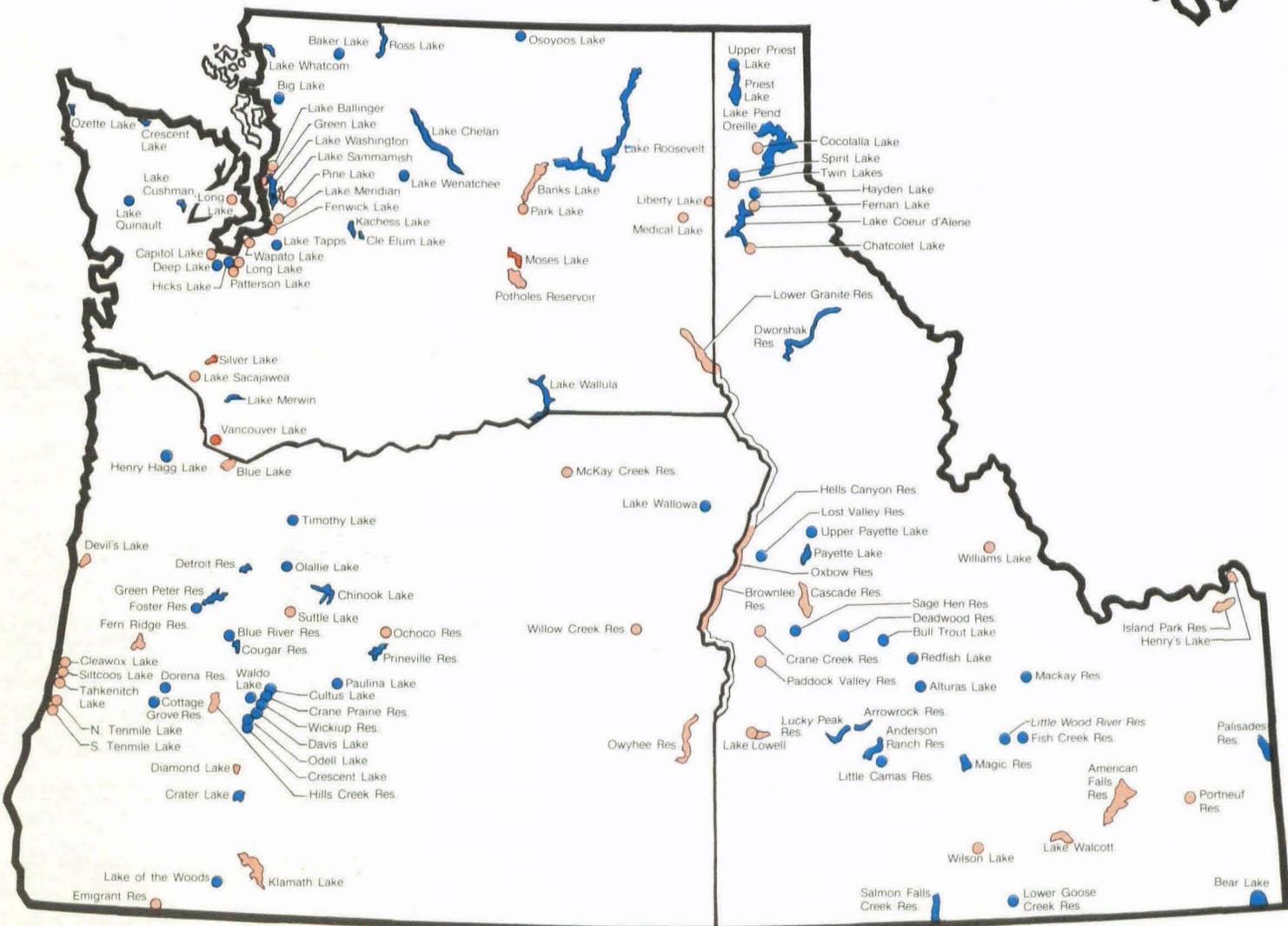
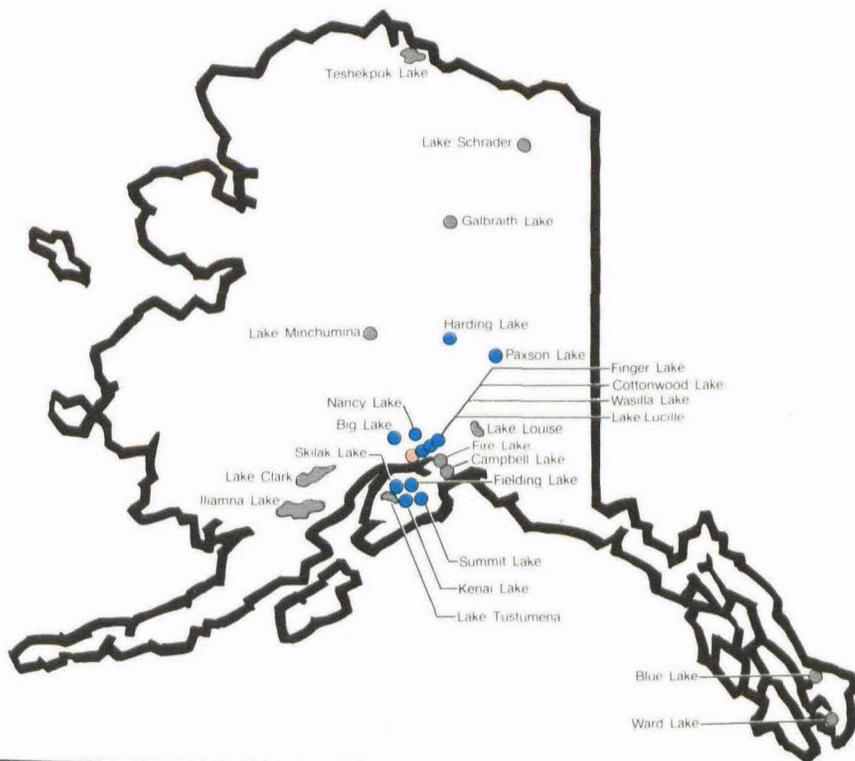


Figure 37.
Water Quality of Principal
Recreational Lakes in Region 10.

- LITTLE OR NO IMPAIRMENT
- MODERATE IMPAIRMENT
- SIGNIFICANT IMPAIRMENT
- STATUS UNKNOWN



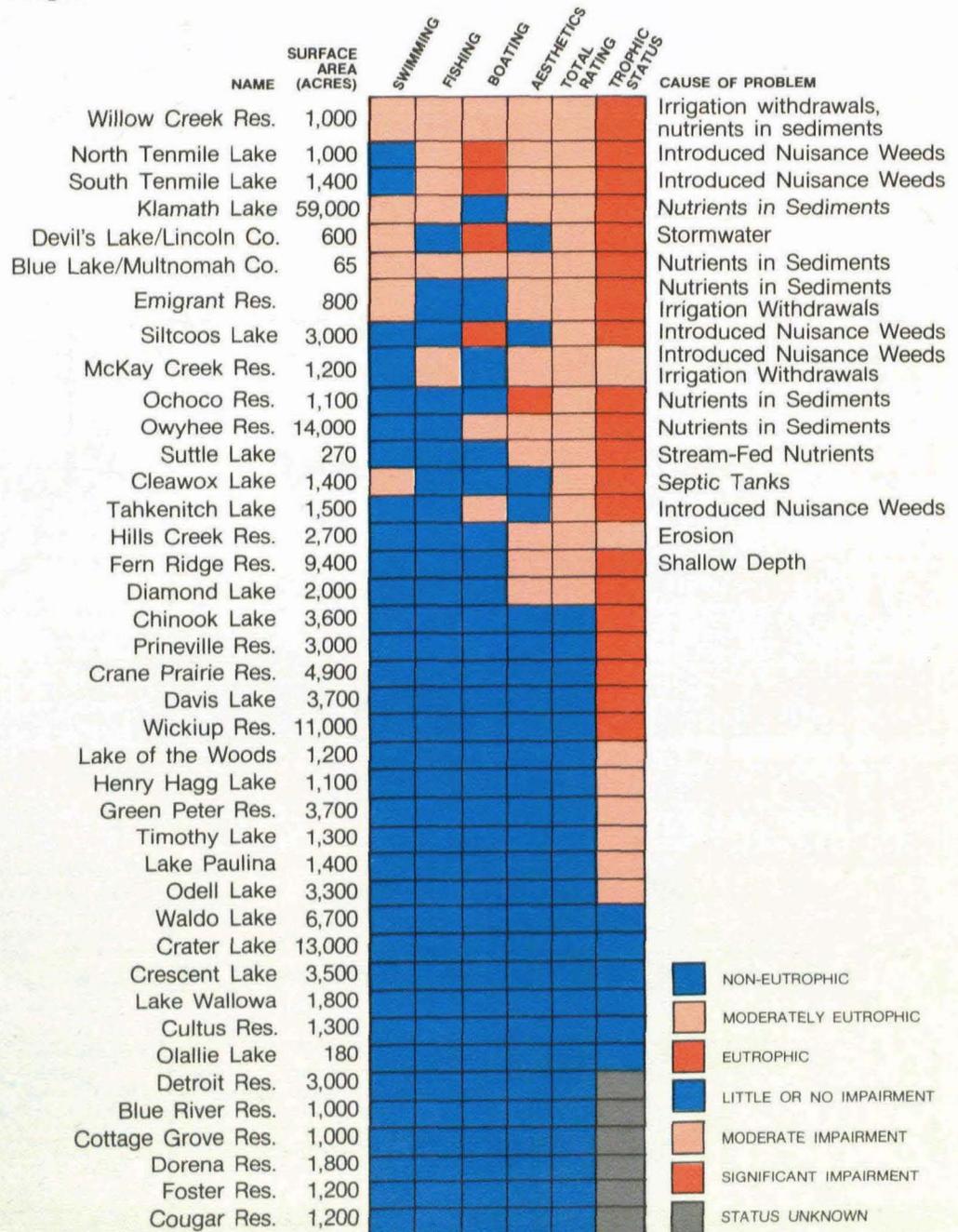
Oregon Lake Water Quality

Figure 38 shows the extent and major causes of use impairment for the principal recreational lakes in Oregon. Seventeen of these lakes are moderately impaired, mostly due to aesthetic conditions (algae blooms) and aquatic weed growths. Nutrients that support the weed and algal growths are, in some cases, supplied by bottom muds accumulated from soil erosion, and in others are due to septic drainage from recreational and residential development.

The quality of a few of these lakes has been at least partially restored. Commonwealth Lake near Portland, for example, which suffered from algae blooms and proliferation of aquatic weeds, was successfully restored by dredging and flushing with water diverted from a nearby creek. Riprap, bulkheads, and a perimeter walkway reduced siltation in the lake. In Diamond Lake, Douglas County, nutrients from sewage had accelerated eutrophication. Sewage was diverted from the lake drainage, and fish-cleaning and trailer-dumping stations were installed to further limit nutrients reaching the lake. Other lakes still have problems. Blue Lake near Portland, for example, has high recreational potential, but it is highly eutrophic with summer blooms of algae. This is due in part to a nutrient-rich water supply. On the coast, Devil's Lake experiences rapid siltation due to stormwater runoff. Feasibility studies have been initiated under the Clean Lakes Program for the restoration of Devil's Lake, Klamath Lake, Fern Ridge Reservoir, Sturgeon Lake, and Mirror Pond.



Figure 38.
The Recreational Impairment and Trophic Status of Principal Recreational Lakes in Oregon



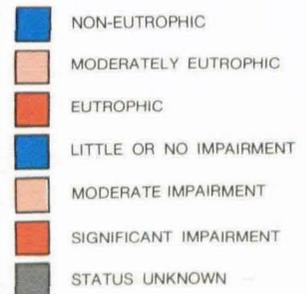
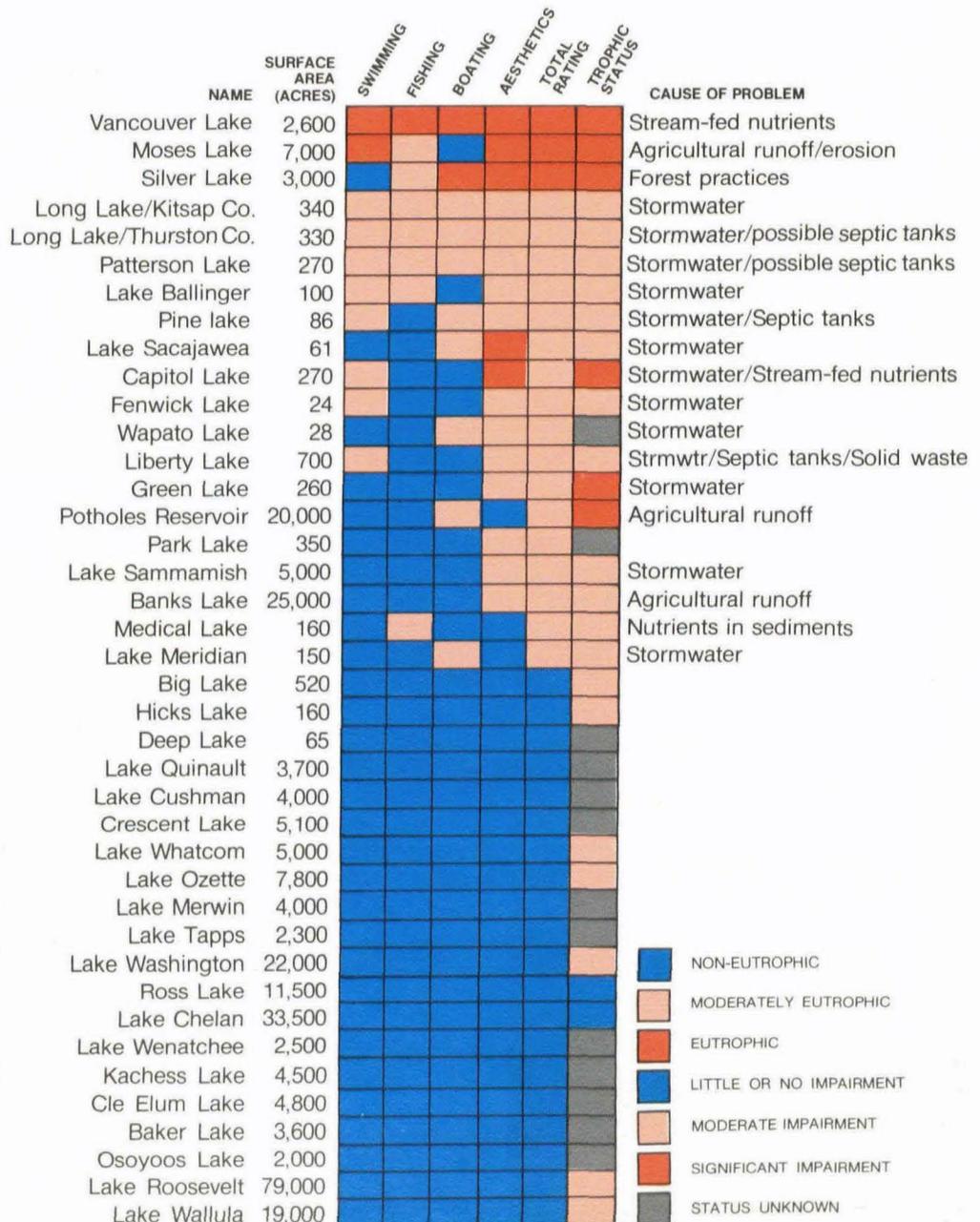
Washington Lake Water Quality

Figure 39 shows the extent and major causes of use impairment for the principal recreational lakes in Washington. Vancouver Lake, Moses Lake, and Silver Lake are considered significantly impaired in two or more respects. Another 17 lakes are moderately impaired, mostly due to aesthetic conditions. Most of the lakes with water quality problems receive stormwater runoff and septic tank seepage from lakeside residential areas. The large lakes and reservoirs of eastern Washington receive irrigation return flows and runoff from agricultural lands that contain fertilizers and animal wastes which accelerates the eutrophication processes.

Some measures are being implemented through the state and Federal programs to restore recreational amenities. For example, Medical Lake was treated with alum to precipitate excess phosphorous to the lake bottom, to form a layer over the sediments. This treatment resulted in a 90% reduction in phosphorous and substantially reduced the algal growths. Spada-Chaplain Lake had high levels of turbidity which were reduced by re-routing stream channels and stream beds to reduce erosion of clay into the lake and by revegetating the banks of the lake. Plans to improve water quality in Vancouver Lake and Lake Sacajawea include dredging, dilution, and control of polluting urban and agricultural runoff.



Figure 39. The Recreational Impairment and Trophic Status of the Principal Recreational Lakes in Washington



Idaho Lake Water Quality

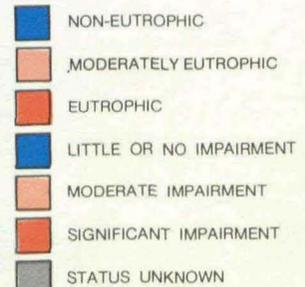
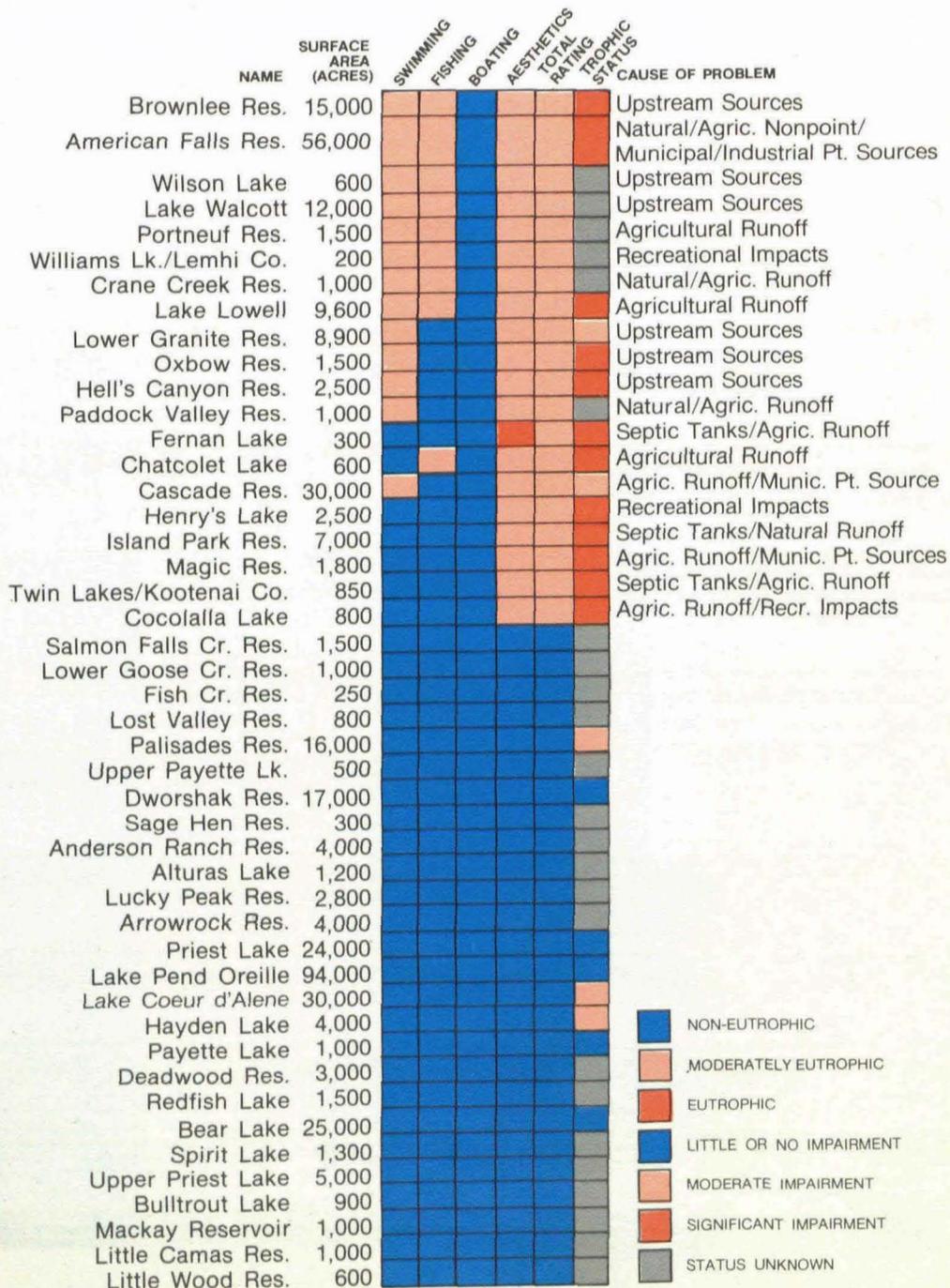
Figure 40 shows the extent and major causes of use impairment for the principal lakes in Idaho. Most impairments appear to be due to algal blooms stimulated by nutrients from agricultural runoff and septic tanks. Runoff from agricultural non-point sources entering the Snake River upstream of Oxbow and Brownlee Reservoirs has degraded these two lakes. Lake Lowell, an off-stream reservoir near Boise, receives heavy recreational usage by residents of the Boise Valley. Excessive algal growth in the summer impairs such use. The photosynthetic activity and eventual decomposition of the algae reduce the dissolved oxygen levels, which may be adversely affecting the fishery resource of the reservoir. These conditions are primarily due to the nutrient enrichment of summer inflows by agricultural non-point sources.

The water quality of American Falls Reservoir is affected by nutrients from dryland and irrigated agriculture, winter discharges of treated sewage effluent from Pocatello, phosphate deposits in the soils, and from many springs in the area.

Measures are being considered to restore a few of these lakes. Studies have been performed to better define sources of nutrients and the other water quality problems in Lake Lowell. No restoration program has been initiated, however. The wastewater from the Simplot Plant at Pocatello and summer discharges from the Pocatello sewage treatment plant have been removed from the Portneuf River, which flows into the American Falls Reservoir. This, plus the eventual application of best management practices to agriculture, should reduce this reservoir's problems considerably.



Figure 40.
The Recreational Impairment and Trophic Status of the Principal Recreational Lakes in Idaho



Alaska Lake Water Quality

Little is known about most Alaska lakes. Several of the more readily accessible lakes near Anchorage are exhibiting signs of advancing eutrophication and recreational use impairment as shown in Figure 41.

Recently the state studied certain lakes in the Palmer-Wasilla area, a fertile farming region near Anchorage which is experiencing rapid residential development. The population has grown by 15 to 20 percent a year over the past 3 years. The Alaska Department of Fish and Game has found 36 of over 100 lakes with low dissolved oxygen in the winter, although the cause is unknown. For many lakes, it may be a natural condition; however, human activities may be a contributing factor.

The trophic conditions of four lakes near Wasilla (Lucille, Wasilla, Cottonwood, and Finger) were studied more intensely. All are heavily used for recreation, and the public has expressed some concern about water quality. Of the four, Lucille is the most shallow, with a mean depth of 1.7 meters, and also the most eutrophic. In winter dissolved oxygen levels drop to almost zero, and the lake has a history of fish kills. There is considerable algae growth in the summer, though not yet to the extent that it interferes with boating. The lake is not used much for swimming since it is so shallow. The other three lakes are deeper and are only moderately eutrophic, with some algae growth in isolated portions of the lakes.

Alaska is becoming involved in the Clean Lakes Program and other problem lakes are being identified.

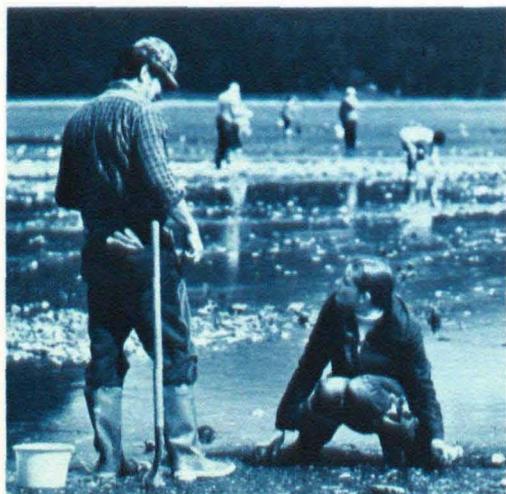


Figure 41.
The Recreational Impairment and Trophic Status of the Principal Recreational Lakes in Alaska

| NAME | SURFACE AREA (ACRES) | SWIM | FISH | BOAT | AESTH. | TOTAL RATING | TROPHIC STATUS | CAUSE OF PROBLEM |
|------------|----------------------|-------------------------|-------------------------|-------------------------|-------------------------|------------------------|----------------------|---------------------------------------|
| Lucille | 362 | Moderate Impairment | Little or No Impairment | Significant Impairment | Moderate Impairment | Significant Impairment | Eutrophic | Septic Tanks |
| Campbell | | Moderate Impairment | Little or No Impairment | Significant Impairment | Moderate Impairment | Moderate Impairment | Moderately Eutrophic | Sewage overflow and stormwater runoff |
| Wasilla | 334 | Little or No Impairment | Moderate Impairment | Moderately Eutrophic | |
| Cottonwood | 250 | Little or No Impairment | Moderate Impairment | Moderately Eutrophic | |
| Finger | 362 | Little or No Impairment | Moderate Impairment | Moderately Eutrophic | |
| Harding | | Little or No Impairment | Moderate Impairment | Moderately Eutrophic | |
| Fielding | | Little or No Impairment | Moderate Impairment | Moderately Eutrophic | |
| Summit | | Little or No Impairment | Moderate Impairment | Moderately Eutrophic | |
| Paxson | | Little or No Impairment | Moderate Impairment | Moderately Eutrophic | |
| Big | | Little or No Impairment | Moderate Impairment | Moderately Eutrophic | |
| Kenai | 12,160 | Little or No Impairment | Moderate Impairment | Moderately Eutrophic | |
| Skilak | 34,320 | Little or No Impairment | Moderate Impairment | Moderately Eutrophic | |
| Fire | | Little or No Impairment | Moderate Impairment | Moderately Eutrophic | |
| Nancy | | Little or No Impairment | Moderate Impairment | Moderately Eutrophic | |
| Galbraith | | Little or No Impairment | Moderate Impairment | Moderately Eutrophic | |
| Clark | 70,400 | Little or No Impairment | Moderate Impairment | Moderately Eutrophic | |
| Iliamna | 640,000 | Little or No Impairment | Moderate Impairment | Moderately Eutrophic | |
| Minchumina | 14,720 | Little or No Impairment | Moderate Impairment | Moderately Eutrophic | |
| Louise | 14,720 | Little or No Impairment | Moderate Impairment | Moderately Eutrophic | |
| Schrader | | Little or No Impairment | Moderate Impairment | Moderately Eutrophic | |
| Tustumena | 74,880 | Little or No Impairment | Moderate Impairment | Moderately Eutrophic | |
| Ward | | Little or No Impairment | Moderate Impairment | Moderately Eutrophic | |
| Blue | | Little or No Impairment | Moderate Impairment | Moderately Eutrophic | |



Marine Water Quality



Coastal and estuarine waters contribute greatly to the commercial and recreational assets of the Northwest. While the majority of these waters are relatively free of pollution, there is some generally localized contamination from municipal sewage discharge and from agricultural and logging operations carried to estuaries by some rivers.

How Marine Water Quality is Determined

Since sampling and analysis of marine water is complex and expensive, the amount of available data is limited, and a marine water index has not been devised. The quality of certain saltwater areas, however, can be inferred from the condition of shellfish. Shellfish concentrate disease-causing bacteria, viruses, toxic chemicals, and other contaminants from the water in which they live. Consequently, shellfish indicate the degree of pollution in marine waters and provide an indirect way of assessing the success of pollution control efforts.

In this report, marine water quality determinations are based upon criteria designed for human consumption of shellfish, which are established by the U.S. Food and Drug Administration for the National Shellfish Sanitation Program. Waters that are free from fecal contamination (bacteria from sewage), industrial wastes, radioactive elements, and

biotoxins (certain naturally produced poisons) are classified as "approved for commercial shellfish harvesting." "Conditionally approved" waters may be closed when seasonal increases in population, freshwater runoff containing contaminants at certain times of the year, or temporary malfunctioning of wastewater treatment plants result in failure to meet the criteria. Waters found to be contaminated or suspected of being contaminated, which would produce shellfish unsafe for human consumption, are classified as "closed."

The Regional Overview

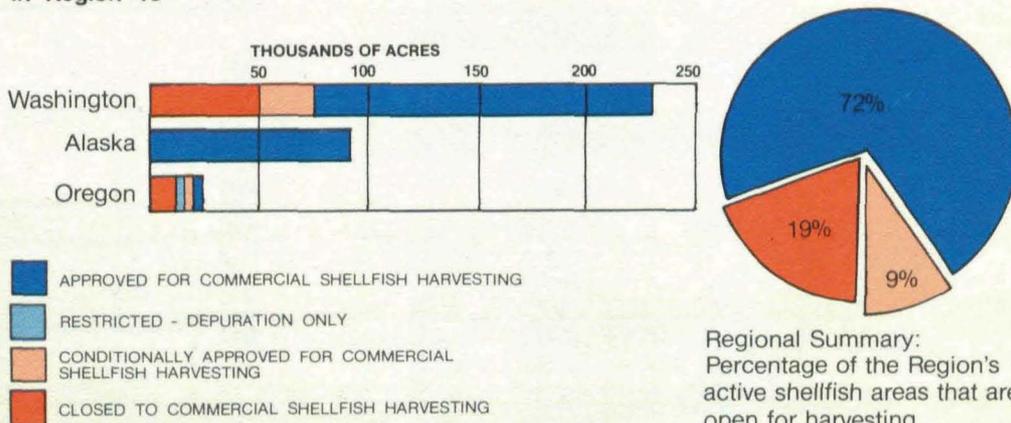
A total of 349,000 acres has been classified as commercial shellfish growing area in Region 10 (see Figure 42). This represents approximately 2 percent of the classified growing waters in the Nation. Of the regional growing area, 72 percent is classified as approved, 9 percent conditionally approved, and 19 percent closed. Regionally, Washington contains the largest percentage of the total classified area (65 percent or 228,900 acres), followed by Alaska (27 percent or 92,400 acres), and Oregon (8 percent or 28,100 acres).

Information on the quality of many marine waters used for swimming and recreational shellfish harvesting is quite limited. Until more

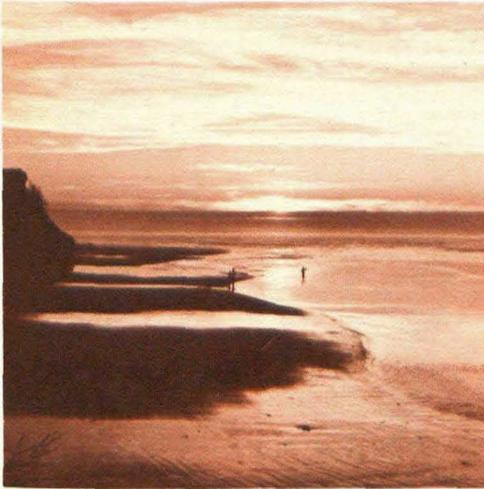


is obtained, it is generally not recommended that these pursuits be undertaken near sewage treatment plant discharges, in areas subject to septic tank drainage, or in areas known to receive agricultural, livestock, or industrial wastes. When in doubt about the status of a swimming beach or "sports" shellfish area, individuals should contact their county or state health agency for current information about the quality of the waters in question.

Figure 42. Status of Classified Shellfish Growing Areas in Region 10



Regional Summary: Percentage of the Region's active shellfish areas that are open for harvesting.

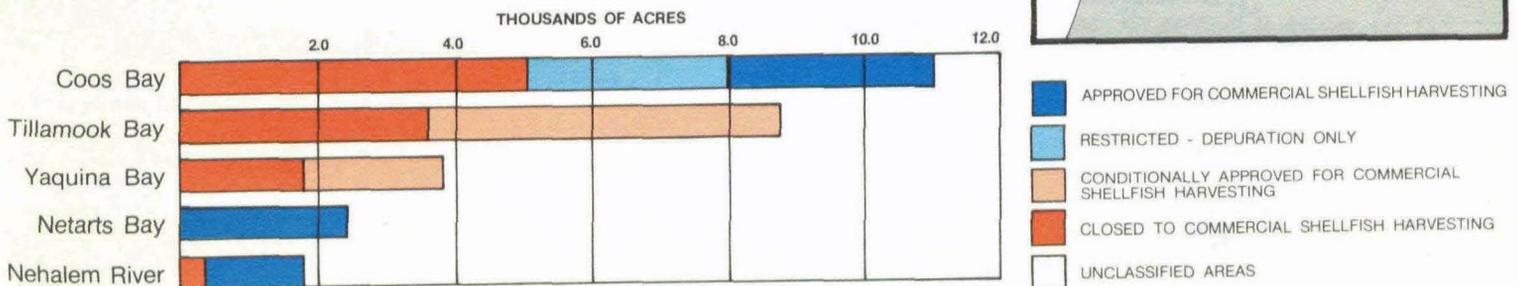


Oregon's Marine Waters

Of the 28,100 acres of classified commercial shellfish growing waters in Oregon, about 25 percent are currently approved for commercial harvesting and 25 percent are conditionally approved, depending on specific conditions that are monitored throughout the year. Ten percent have recently been reclassified from closed to "restricted—for depuration only" (see below). The remaining 40 percent are classified as closed and cannot be used to produce shellfish for human consumption. Figure 43 shows the location of the classified waters in Oregon.

Figure 44 indicates that almost one-third of Coos Bay is closed to commercial shellfishing because of bacterial pollution from sewage

Figure 44. Status of Classified Shellfish Growing Areas in Oregon

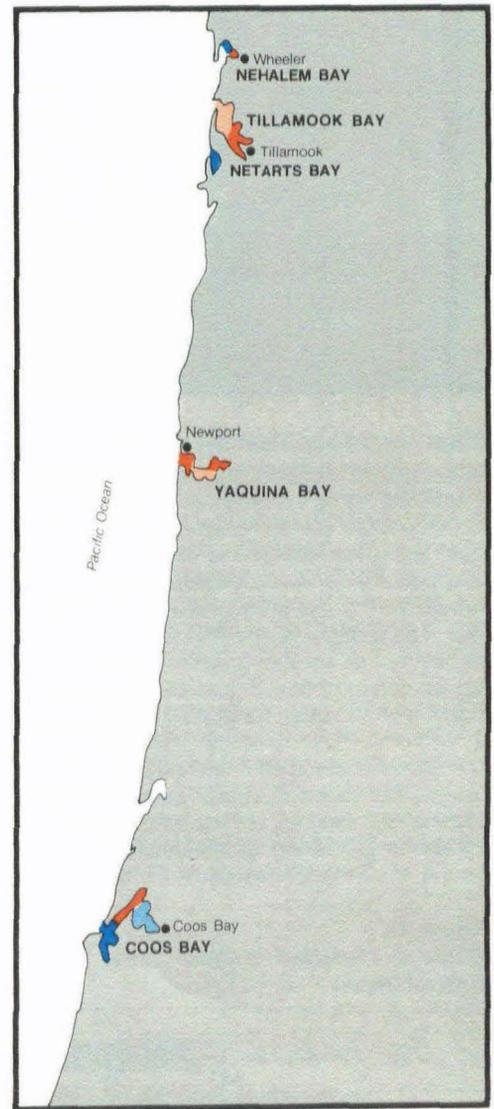


treatment plant discharges, although the South Slough of Coos Bay is approved for commercial shellfish harvesting. The state has recently reclassified the inner portions of Coos Bay from closed to "restricted—for depuration only." (Depuration is a process shellfish can be subjected to which reduces bacterial contamination to acceptable levels by utilizing their natural purification abilities.) Commercially grown shellfish from this area must be so treated before they are harvested for sale to the public.

Potential treatment plant failures as well as a number of non-point sources of fecal pollution have made it necessary to close or only conditionally approve Tillamook Bay for shellfish harvest. Areas of Yaquina Bay are either closed or conditionally approved due to non-point source and industrial pollution problems. The Nehalem River also has problems related to non-point source pollution and increasing population density. Netarts Bay, although not a major commercial shellfish growing area, is considered to have good water quality suitable for oyster culture.

Several measures are being taken to restore Oregon's marine waters for shellfish harvest. Sewage treatment improvements planned for the cities of Coos Bay and North Bend should reduce bacterial pollution in Coos Bay. The City of Tillamook is constructing a new sewage treatment plant, and an EPA-funded project is underway to identify non-point sources of pollution around Tillamook Bay, after which a pollution control plan will be prepared.

Figure 43. Water Quality Map of Oregon's Commercial Shellfish Growing Areas





Washington's Marine Waters

Of the 228,900 acres of classified commercial shellfish growing waters in Washington, about 68 percent are currently approved for commercial harvesting and 11 percent are conditionally approved, depending on specific conditions that are monitored throughout the year. The remaining 21 percent are closed and cannot be used to produce shellfish for human consumption. Figure 45 shows the location of classified waters in Washington.

The extent of closures in the various commercial shellfish areas is shown in Figure 46. The approved areas include most of Willapa Bay, northern and southern Puget Sound, the Strait of Juan de Fuca, and all of

Hood Canal and the Pacific Ocean beaches. Central Puget Sound is mostly closed, due to potential pollution arising from the urban-industrial areas of Seattle, Tacoma, and Bremerton. Municipal sewage treatment plant discharges and septic tank problems also contribute to closures. In Burley Lagoon, for instance, 135 acres of oyster-growing area were closed when the lagoon was polluted with fecal material from domestic septic tanks and nearby pastures. Industrial waste discharges along the Tacoma waterfront have occasionally degraded water quality and caused fish kills.

On occasion, harvesting has had to be restricted in northern and central Puget Sound because of increased levels of paralytic shellfish poison. This is a naturally occurring substance commonly known as "red tide." Some water quality improvements have been noted in Everett and Bellingham due to reduced effluents from the pulp mills in the area, but additional improvements are needed.

Less than half of the available shellfish growing area of Grays Harbor is approved for use. Major point source contributors are pulp mills and inadequate sewage treatment, although improved waste treatment programs have reduced their contributions. Agricultural activities, coupled with seasonal fluctuations in freshwater runoff also contribute to water quality problems. In Willapa Bay, discharges from municipal sewage treatment plants in the vicinity of South Bend and Raymond are

Figure 45.
Water Quality Map of Washington's Classified Commercial Shellfish Growing Areas

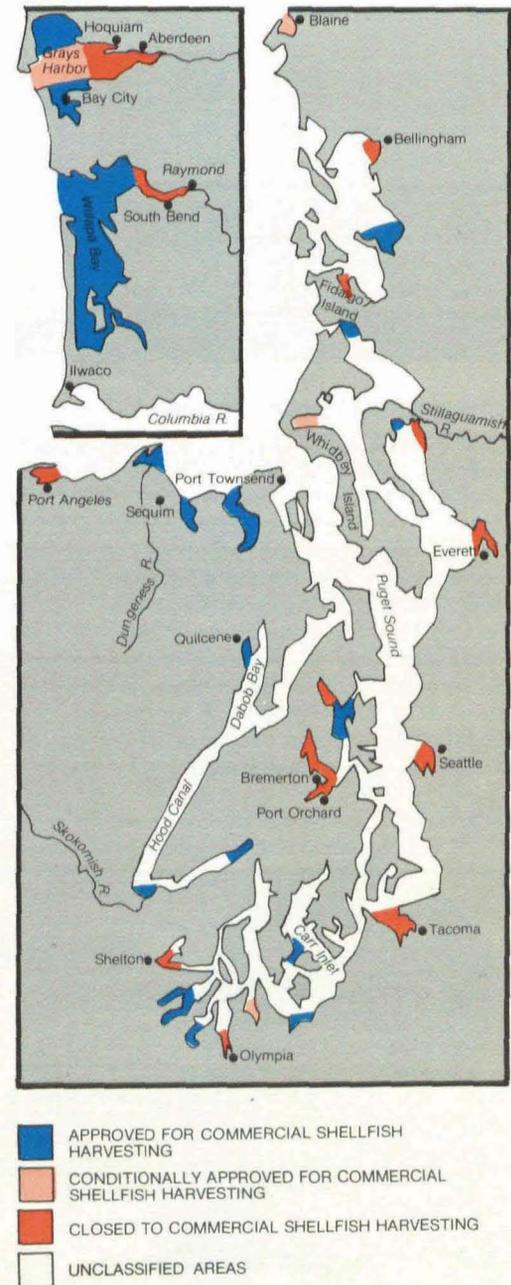
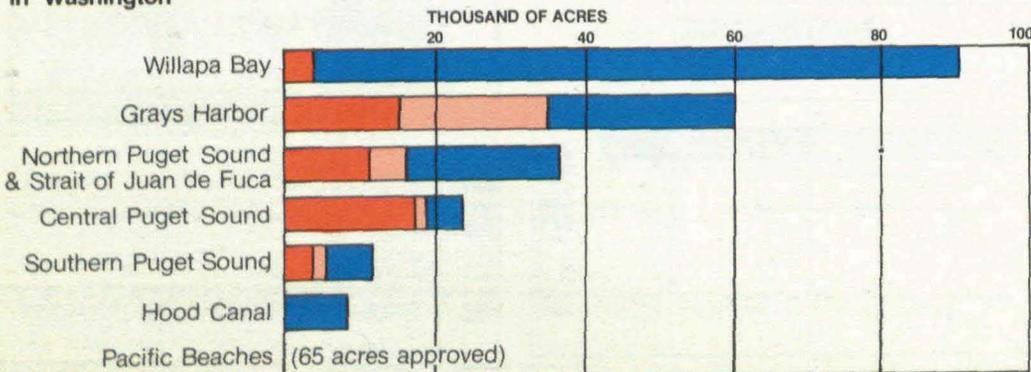


Figure 46.
Status of Classified Shellfish Areas in Washington



primarily responsible for the closure of a small part of the bay to oyster harvesting.

Because of wastewater treatment programs, marine water quality in Washington has improved in recent years. For example, improved water treatment programs at Grays Harbor pulp mills have reduced the contribution of these sources and should reduce them further in the future. However, further reductions in contamination from sewage treatment plants and industrial discharges will be required to restore those waters conditionally approved or closed to shellfish harvesting. At the same time, care must be taken to maintain high quality areas. The Pierce County Commissioners have passed a resolution establishing Burley Lagoon and three other shellfish growing areas in Pierce County as "environmentally sensitive" areas. Population growth along Hood Canal, for instance, could create problems in the future.

Alaska's Marine Waters

Of the 92,400 acres of commercial shellfish growing area that have been classified in Alaska (see Figure 47), all are open to the harvest of shellfish (razor clams only). The remaining areas are unclassified because they have not been surveyed or monitored for the presence of paralytic shellfish poison. Alaska's 33,904-mile shoreline encompasses vast amounts of estuarine and freshwater wetlands that provide important habitat for aquatic species. EPA and the State of Alaska are taking an active role in regulating dredging, filling, and draining, and other activities that reduce wetland habitat.

Although no Alaskan coastal waters are closed to shellfish harvesting, the state has a potential problem with chronic, low-level oil pollution in certain areas, such as upper Cook Inlet and Port Valdez. This oil comes from such sources as urban runoff, ballast discharges, and disposal of "formation water" (wastewater from oil production platforms and onshore wells discharging into coastal waters). Oil terminal facilities, tanker traffic, and petroleum production also generate potentials for large oil spills. In 1976, the Alaska State Legislature enacted legislation which includes a comprehensive oil spill prevention program. Timely implementation



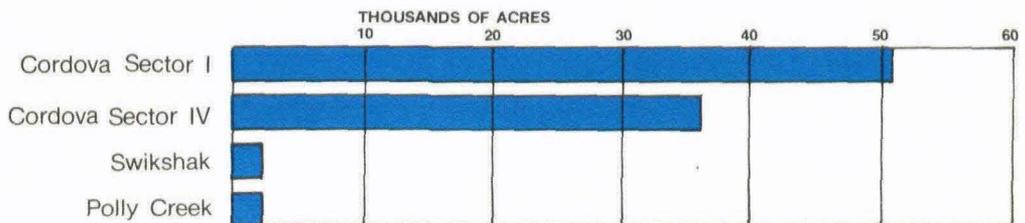
of this program, together with the contingency plan which has recently been developed to deal with oil spills, will help the state address problems associated with petroleum industries.

Alaska Lumber and Pulp Company and Louisiana-Pacific have submitted water quality data to the state that reveal depressed dissolved oxygen and pH levels and some high sulfite waste liquor concentrations in Silver Bay near Sitka and Ward Cove near Ketchikan, where the two plants are located. Seafood processing also contributes significant levels of nutrients to marine waters. EPA and the State of Alaska recently conducted studies at Petersburg, Juneau, Ketchikan, Akutan, Cordova, and Dutch

Harbor to determine the environmental impact of seafood processors' waste disposal practices. In Dutch Harbor, these wastes covered the bottom more rapidly than they could be dissipated, resulting in areas of oxygen depletion and hydrogen sulfide gas production. Processors operating at other locations do not seem to be causing persistent pollution problems.

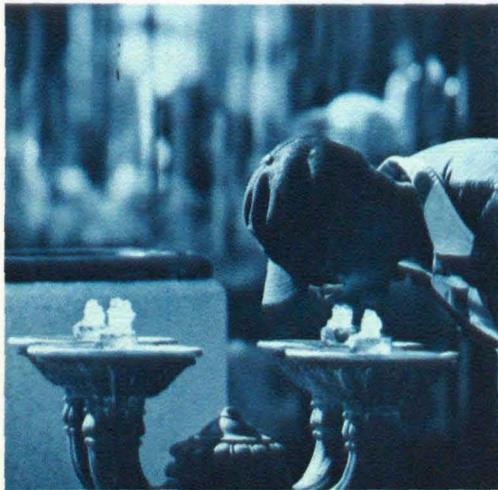
Most seafood processors and pulp mills are presently increasing their treatment levels. As additional industrial treatment needs are met, water quality in localized areas should improve. In other areas, however, increasing environmental pressures will be experienced due to the expanding commercial fishing industry.

Figure 47.
Status of Classified Shellfish Growing Areas in Alaska



Areas depicted represent only those portions of the total estuarine and coastal areas that have been classified by the Alaska State Department of Health and Social Services.

Drinking Water Quality



The drinking water supplied to most residents of the Pacific Northwest and Alaska is considered safe; however, waterborne disease outbreaks occasionally occur. In April 1980, over 200 persons in a Washington community became ill from a waterborne disease (suspected to be giardiasis), and during the fall of 1979, 4 communities in Oregon experienced waterborne outbreaks of giardiasis and gastroenteritis affecting over 150 persons. In addition to acute problems such as giardiasis, long-term or chronic disease may result from ingesting water containing certain inorganic or organic chemicals, as well as radioactive materials. Few water systems, however, are expected to exceed chemical or radiochemical standards; therefore few, if any, cases of chronic diseases are expected.

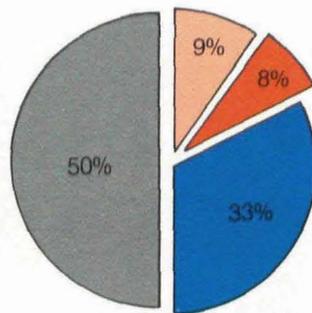
Public Water System Program

The Safe Drinking Water Act, passed in 1974, gave EPA primary responsibility for establishing drinking water standards and assuring national program consistency, but intended that the states implement programs ensuring public water systems' compliance with standards.

In Region 10, Alaska, Idaho, and Washington have assumed primary responsibility for working with public water systems to implement drinking water standards. Oregon has chosen not to assume primary responsibility. Consequently, since July 1977, EPA has worked directly with Oregon's public

Figure 48.

a. Regional Summary Based on Percentage of Community Water Systems



b. Regional Summary Based on Population Served by Community Water Systems

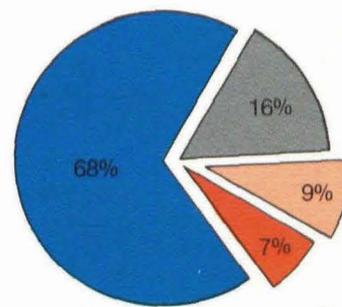
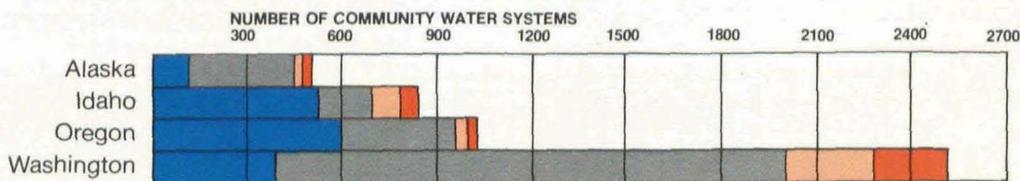


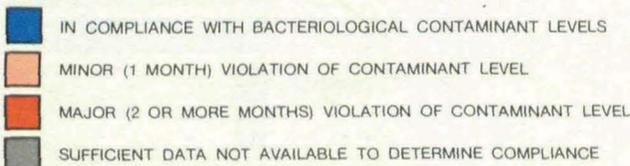
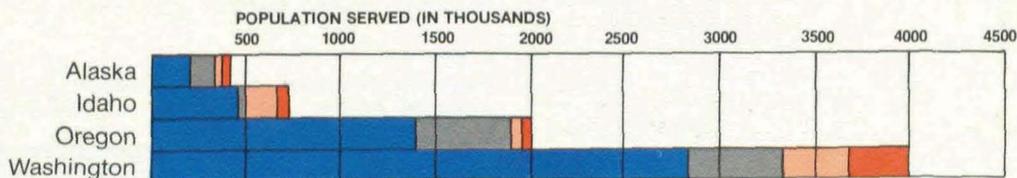
Figure 49.

Compliance with EPA Drinking Water Standards

a. Community Water Systems



b. Persons Served by Community Water Systems



water systems to implement the provisions of the Safe Drinking Water Act. More recently, EPA and the Oregon State Health Division (OSHD) joined forces to take advantage of an existing working relationship whereby OSHD agreed to cover the drinking water program at facilities for which it issues food services or similar licenses. Thus both EPA and OSHD work with public water systems. Emphasis has been placed on voluntary compliance with the National Interim Primary Drinking Water Regulations, but when voluntary efforts fail, EPA has been pursuing more formal enforcement procedures.

The national drinking water standards address finished water quality characteristics, as measured in periodic tests. EPA recognizes that these are minimum standards and are not adequate in themselves to protect public health. Therefore, EPA encourages states to implement comprehensive programs that go beyond just addressing finished water quality.

The primary means to assure safe drinking water is for public water systems to have properly operated, well-maintained, adequate facilities. A major part of a state's program, therefore, is evaluation of facility design and inspection of water systems to determine facility deficiencies which may present health hazards. Two Region 10 states, Alaska and Washington, have state funding programs that provide financial assistance to municipally owned water systems for facility improvements. To ensure proper operation and maintenance, Alaska and Washington also have mandatory operator certification programs. Idaho and Oregon have voluntary certification programs. All four states, to varying degrees, sponsor or assist in operator training activities. Also, to help ensure proper water system operation and maintenance in Washington, the state is implementing a satellite support system program whereby operation of small systems is provided by a highly qualified regional support organization.

Fiscal year 1979 represented the second full year of implementation of the national drinking water standards. The bacteriological data from FY79 are presented in Figures 48 and 49. While a significant percentage (50%) of Region 10's 4,800 community water systems are not yet conducting adequate bacteriological water quality monitoring, the

total population served by these systems is relatively small (16%), indicating that these systems serve predominantly small numbers of people.

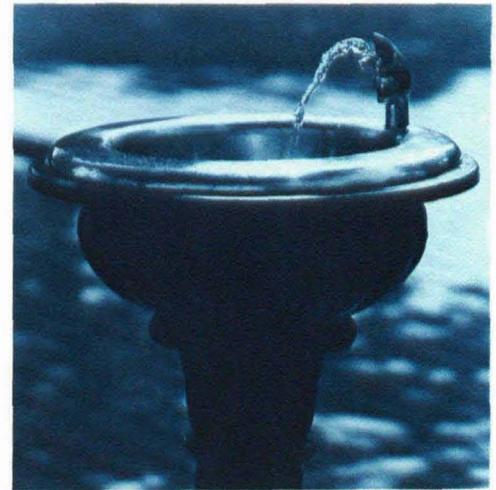
Seventeen percent of the Region's water systems, which serve approximately 16 percent of the population, experienced either major or minor bacteriological standard violations during FY79. While many causes of these violations have been corrected, the number of standards violations actually noted may increase over the next few years as more systems conduct required monitoring.

Chemical monitoring data are not yet available for many of Region 10's public water systems; however, information presently available indicates that very few systems will fail to meet chemical standards. Public water systems using surface water sources are also required to monitor for turbidity. Current data indicate that many systems will be unable to continuously comply with the turbidity standard. These systems will require development of a ground water source, installation of filtration for the surface water source, or interconnection with a system presently meeting standards for safe drinking water.

Ground Water Protection

The Safe Drinking Water Act also established a program to protect underground sources of drinking water (ground water). EPA's role is to develop national Underground Injection Control (UIC) regulations, provide oversight, and ensure national program consistency. Congress intended for the states to implement the UIC Program and that EPA would list, over a period of time, the states needing the program. Washington and Oregon were listed in June 1979. Idaho, although not initially listed, petitioned on July 30, 1979, to be included in the initial UIC listing. Alaska was listed in March 1980.

The UIC Program in Region 10 was initiated by the awarding of EPA grants to Idaho and Washington during December 1979. Alaska and Oregon have chosen not to participate. Idaho and Washington are using their developmental grant funds to collect background data on aquifers, inventory injection wells, and evaluate the adequacy of state laws and regulations for primary

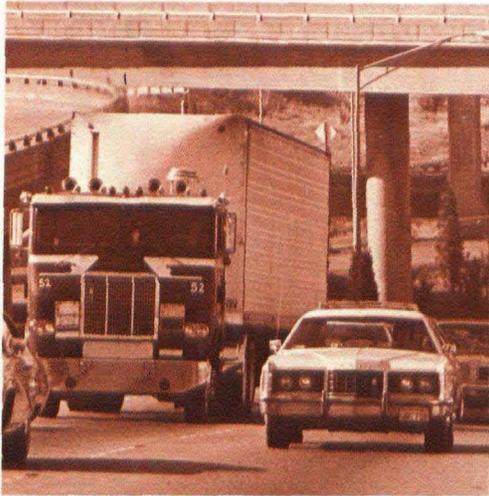


surveillance and enforcement authority. EPA, in conjunction with the U.S. Geological Survey and Oregon State University, is collecting background information for EPA implementation of a UIC Program in Oregon. For the State of Alaska, EPA has a similar agreement with the University of Alaska. EPA will also be responsible for UIC activities on Indian lands throughout the Region. The UIC Program will provide additional protection for the Region's ground water resources from the practices of well injection of fluids.

The Region's surface impoundment assessment (pits, ponds, and lagoons) has been completed. Approximately 1,200 sites, accounting for over 2,500 individual impoundments, were inventoried. While the study indicates there is a high potential for the impoundments to contaminate ground water, to date few actual cases of ground water contamination have been documented.

"Sole source aquifer designation" is another feature of the national ground water protection program. In 1979, the Region entered into its first full year of implementing protective activities within the Spokane Valley-Rathdrum Prairie Aquifer. This aquifer, first designated a sole source aquifer in 1978, provides drinking water for about 40,000 Idaho residents and 300,000 Washington residents in the Coeur d'Alene and Spokane areas. The designation prohibits any Federal agency from financially assisting any project which EPA determines may contaminate this important aquifer.

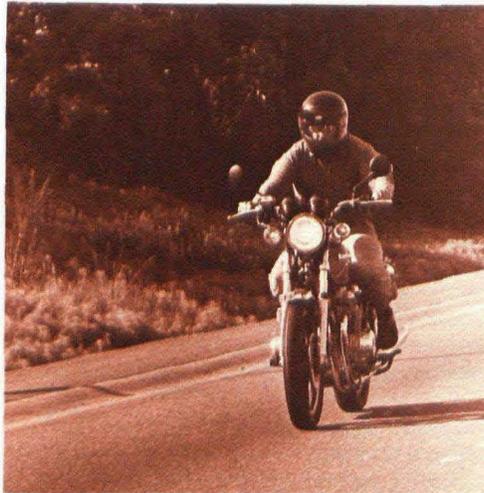
Noise



Only during the past few years has noise been recognized as a major environmental issue. In Region 10, noise is not a major problem as compared to other highly urbanized areas. Noise control throughout Region 10 is being addressed by state and local agencies, with the assistance of EPA, through studies, establishment of standards, rules, and regulations. The problem is not limited to acute situations such as occupational noise that causes hearing loss, but also includes chronic community noise, which affects us physically and mentally by causing nervousness, tension, and loss of sleep. Transportation noise dominates the problem—airplanes, trucks, passenger vehicles, motorcycles, motorboats, and snowmobiles are all contributors.

The Federal Noise Control Act of 1972 authorizes EPA to set noise standards for cars, trucks, interstate railroads, aircraft, etc. However, primary responsibility for control of noise rests with state and local governments. EPA has assisted Oregon and Washington in developing noise regulations, has helped Anchorage, Seattle, and Portland develop noise control ordinances, and has assisted with monitoring of noise levels from railroad locomotives, ferries, and auto and motorcycle racetracks.

No state agency has statutory responsibility for noise control in Alaska, and few local governments have noise abatement ordinances. In December 1978, the City of Anchorage adopted a comprehensive noise



control ordinance covering land use and motor vehicle noise. Law enforcement personnel are trained to enforce the motor vehicle standards. Fairbanks is being assisted through an EPA grant and the University of Washington Regional Noise Technical Assistance Center, to conduct a physical noise survey that will identify major noise sources.

Idaho has no state noise control program for stationary or motor vehicle noise sources that is actively enforced. The Lewiston City Council recently directed the Mayor to appoint a citizens' committee to study noise control and they expect a proposed comprehensive noise ordinance by November 1980. Other than the current efforts in Lewiston, the only local ordinances that exist deal with nuisance-type noises.

Oregon's Department of Environmental Quality (DEQ) has developed and enforced noise control rules since 1974. Rules setting noise emission limits for new motor vehicles, including cars, trucks, buses, motorcycles, snowmobiles, and motorboats, require manufacturers and Oregon dealers to meet applicable rules and standards. In-use operational standards have been established for motor vehicles to ensure noise control equipment has neither deteriorated nor been modified to significantly increase noise emissions. Such in-use motor vehicle standards are being implemented by appropriate enforcement jurisdictions throughout the state. Through ambient noise

standards, residential and other noise sensitive property is protected from excessive noise emissions by industrial and commercial activities. These standards are primarily enforced upon verification of a citizen complaint. New industrial and commercial sources are subject to ambient limits as well as nondegradation standards. Airport noise is controlled under rules that require airport proprietors to develop an airport noise abatement program, with land use controls as well as airport operational controls. Presently, over 40 technical staff people on a part-time basis are trained and involved in the implementation of the DEQ noise control program.

In addition, DEQ is assisting in development and implementation of city and county noise control programs. Often noise is a local problem needing local resolution; therefore, DEQ is providing the technical assistance needed by communities to identify their noise sources and develop a control program. Once established, the local program becomes self-sustaining with assistance from DEQ as needed.

Already two Oregon cities, Portland and Eugene, are actively enforcing noise control ordinances. Portland's noise control staff responds to complaints and enforces sound level standards for environmental land use and nuisance noises. In Eugene, a police officer team enforces motor vehicle noise standards.

The Washington Noise Control Act of 1974 gave the Washington State Department of Ecology (DOE) authority to establish standards for stationary noise sources, such as commerce and industry, as well as for motor vehicles and watercraft. DOE is authorized to enforce standards related to land use, while the State Patrol and local law enforcement agencies enforce standards for motor vehicles. DOE is assisting the development and implementation of city and county noise control programs. Again, noise is often a local problem needing local resolution; therefore, DOE is providing the technical assistance needed by communities to identify their noise sources and develop a control program. Once established, the local program becomes self-sustaining with assistance from DOE as needed.



Storm Water Management For Industrial Activities

Developing
Pollution Prevention Plans
And Best Management
Practices

 Printed on Recycled Paper.

FOREWORD

This manual provides industrial facilities with comprehensive guidance on the development of storm water pollution prevention plans and identification of appropriate Best Management Practices (BMPs). It provides technical assistance and support to all facilities subject to pollution prevention requirements established under National Pollutant Discharge Elimination System (NPDES) permits for storm water point source discharges.

EPA's storm water program significantly expands the scope and application of the existing NPDES permit system for municipal and industrial process wastewater discharges. It emphasizes pollution prevention and reflects a heavy reliance on BMPs to reduce pollutant loadings and improve water quality. This manual provides essential guidance in both of these areas.

This document was issued in support of EPA regulations and policy initiatives involving the development and implementation of a National storm water program. This document is Agency guidance only. It does not establish or affect legal rights or obligations. Agency decisions in any particular case will be made applying the laws and regulations on the basis of specific facts when permits are issued or regulations promulgated.

This document will be revised and expanded periodically to reflect additional pollution prevention information and data on treatment effectiveness of BMPs. Comments from users will be welcomed. Send comments to U.S. EPA, Office of Wastewater Enforcement and Compliance, 401 M Street, SW, Mail Code EN-336, Washington, DC 20460.

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CHAPTER

1

INTRODUCTION

Storm water runoff is part of a natural hydrologic process. However, human activities, particularly urbanization, can alter natural drainage patterns and add pollutants to the rainwater and snowmelt that runs off the earth's surface and enters our Nation's rivers, lakes, streams, and coastal waters. A number of recent studies by the U.S. Environmental Protection Agency (EPA), State water pollution control authorities, and various universities have shown that storm water runoff is a major source of water pollution, declines in fisheries, restrictions on swimming, and these conditions limit our ability to enjoy many of the other benefits that the Nation's waters provide.

In response to this problem, the States and many municipalities have been taking the initiative to manage storm water more effectively. In acknowledgement of the importance of the storm water problem, the Congress has directed EPA to undertake a wide range of activities, including providing technical and financial assistance to States and other jurisdictions to help them improve their storm water management programs. In addition, through recent amendments to the Clean Water Act, the Congress has instructed EPA to develop a regulatory program for certain high priority storm water sources.

In carrying out its responsibilities, EPA is committed to promoting the concept and the practice of preventing pollution at the source, before it can cause environmental problems costing the public and private sector in terms of lost resources and the funding it takes to remediate or correct environmental damage.

1.1 PURPOSE OF THIS GUIDANCE MANUAL

This manual provides general guidance on developing and implementing a Storm Water Pollution Prevention Plan for industrial facilities. Owners and operators of industrial facilities will find that putting together a Storm Water Pollution Prevention Plan is a straightforward process that can be accomplished by facility managers and employees.

EPA is publishing this manual for several reasons. The primary purpose of this manual is to provide guidance for industrial facilities that are subject to requirements under EPA's General Permits for storm water discharges associated with industrial activity. Facilities located in the 12 nondelegated States or 6 Territories are subject to these requirements (see Section 1.6 for a list of States and Territories subject to EPA General Permit requirements). EPA anticipates that most storm water discharge permits issued under the Storm Water Program will require a pollution prevention plan. Throughout this manual, specific EPA General Permit pollution prevention requirements are given in the shaded boxes as seen below. Although the requirements for a Storm Water Pollution Prevention Plan may vary from one permit to another, and from State to State, EPA expects that most of the general concepts described in this manual are common to all plan requirements. Please also note that, although this manual presents EPA General Permit requirements that apply to facilities located in nondelegated States and Territories, some of the nondelegated States required modifications or additions to the pollution prevention plan requirements to ensure that the permit complies with State laws and standards. Therefore, it is important that all facilities located in delegated States, as well as nondelegated States, read their permits to determine whether there are

any special conditions. This manual is not intended in any way to substitute for binding legal requirements pursuant to National Pollutant Discharge Elimination System (NPDES) permits.

| EPA GENERAL PERMIT REQUIREMENTS |
|--|
| Storm Water Pollution Prevention Plans |
| Part IV |
| A Storm Water Pollution Prevention Plan shall be developed for each facility covered by this permit. Storm Water Pollution Prevention Plans shall be prepared in accordance with good engineering practices. The plan shall identify potential sources of pollution which may reasonably be expected to affect the quality of storm water discharges associated with industrial activity from the facility. In addition, the plan shall describe and ensure the implementation of practices which are to be used to reduce the pollutants in storm water discharges associated with industrial activity at the facility and to assure compliance with the terms and conditions of this permit. Facilities must implement the provisions of the Storm Water Pollution Prevention Plan required under this part as a condition of this permit. |

In addition to providing guidance for facilities that are subject to storm water permit requirements, this manual contains information that is generally useful for controlling storm water pollution from almost any type of developed site. EPA hopes this manual is widely used in furthering the prevention of pollution at its sources and the adoption of management practices that help us protect the overall quality of the environment.

EPA is also issuing a guidance manual on Best Management Practices (BMPs) for construction activities. If you are subject to requirements under the general permit for storm water discharges associated with construction activities, that manual is designed to help you comply with those somewhat different requirements.

1.2 ORGANIZATION OF THIS GUIDANCE MANUAL

This manual is presented as a user's guide to Storm Water Pollution Prevention Plan requirements. Step-by-step guidelines and accompanying worksheets will walk you through the process of developing and implementing a Storm Water Pollution Prevention Plan. This approach allows you to complete this process in the simplest and most efficient way. The worksheets are designed to help you organize the required information. The remainder of this manual is divided into three sections: Chapter 2 provides information on how to develop a plan; Chapter 3 serves as a resource for selecting activity-specific Best Management Practices (BMPs); and Chapter 4 discusses site-specific BMPs. As you complete each section, you will move through each of the following steps and end up with a fully developed Storm Water Pollution Prevention Plan. Each step is important and should be completed before moving on to the next step. The five major phases involved in developing and implementing your plan are as follows:

| | | |
|---------|---|---------------------------|
| Phase 1 | - | Planning and Organization |
| Phase 2 | - | Assessment |
| Phase 3 | - | BMP Identification |
| Phase 4 | - | Plan Implementation |
| Phase 5 | - | Evaluation |

Chapter 2 provides step-by-step guidance for completing each of these phases. The Organization Phase starts the process by helping you to get organized and by identifying who is going to develop and implement the plan and by identifying site-specific pollution prevention objectives. The Assessment Phase involves gathering information about your site and identifying potential sources of storm water pollution. Using the information collected during the Assessment Phase, you can begin to design the storm water management program that best suits your site. During the BMP Identification Phase, you will evaluate the required baseline BMPs and select other preventive measures. The fourth stage of the Storm Water Pollution Prevention Planning process is the Implementation Phase, during which you put the plan into action. The final step, the Evaluation Phase, allows you to determine if your plan is actually accomplishing your pollution prevention objectives. Periodic reviews, inspections, and evaluations will allow you to keep the plan effective and up-to-date.

In Chapter 3, which details activity-specific BMPs, you will find a number of measures you can use to prevent or reduce the contamination of storm water caused by specific industrial activities. Chapter 4 describes site-specific BMPs. From the list of site-specific BMPs, you can select prevention and control measures that are most appropriate for the physical characteristics of your facility. A combination of these types of BMPs may be most appropriate for your site.

In addition, there are several appendices located at the end of this manual. Appendix A lists the references used to develop this manual. Appendix B includes a glossary of terms. Appendix C provides a model of what a pollution prevention plan might look like for a small industry. Appendix D provides State and Federal storm water and pollution prevention contacts and additional information on pollution prevention. Appendix E provides technical and design fact sheets for some of the storm water BMPs described in Chapter 4. Appendix F describes tests for non-storm water discharges. Appendix G compares Storm Water Pollution Prevention Plan requirements with plan requirements under other environmental programs. Appendix H is a list of reportable quantities for hazardous substances under 40 CFR Parts 117 and 302. Appendix I is the list of water priority chemicals under Emergency Planning and Community Right-to-Know Act (EPCRA), Section 313. Appendix J includes a table of the monitoring requirements that are contained in EPA's General Permits.

1.3 SCOPE OF THIS MANUAL

This manual provides useful information on many pollution prevention and best management practices which you can use to prevent or reduce the discharge of sediment and other pollutants in storm water runoff from your site. This manual describes the practices and controls, tells how, when, and where to use them, and how to maintain them. However, the effectiveness of these controls lies fully in your hands. Although specific recommendations will be offered in the following chapters, keep in mind that careful consideration must be given to selecting the most appropriate control measures based on site-specific features, and on properly installing the controls in a timely manner. Finally, although this manual provides guidelines for maintenance, it is up to you to make sure that your controls are carefully maintained or they will prove to be ineffective.

This manual describes the EPA General Permit requirements for pollution prevention plans. However, requirements may vary from permit to permit. You should read your permit to determine the required components of your pollution prevention plan. Although this manual describes "typical" permit requirements, do not assume that the typical permit requirements described in this manual are the same as your permit requirements even if you are included under an NPDES general permit for storm water discharges associated with industrial activities. Permit conditions may vary between different permits and/or different versions of the permit.

EPA has issued a number of regulations addressing pollution control practices for different environmental media (i.e., land, water, air, and ground water). However, this manual focuses on identifying pollution prevention measures and BMPs specifically for industrial storm water

discharges and provides guidance to industrial facilities on how to comply with storm water permits.

Although Storm Water Pollution Prevention Plans primarily focus on storm water, it is important to consider the impacts of selected storm water management measures on other environmental media (i.e., land, air, and ground water). For example, if the water table is unusually high in your area, a retention pond for contaminated storm water may also lead to contamination of a ground water source unless special preventive measures are taken. Permittees must take these issues into consideration in selecting appropriate pollution prevention measures and should make certain that adoption of storm water measures is consistent with other Federal, State, and local environmental laws. For instance, under EPA's July 1991 Ground Water Protection Strategy, States are encouraged to develop Comprehensive State Ground Water Protection Programs. Your facility's efforts to control storm water should be compatible with the ground water protection objectives reflected in your State's program.

1.4 DEFINITIONS

As you use this manual to select pollution prevention approaches, you will see two key phrases used frequently: "pollution prevention plan" and "best management practice." A solid understanding of these terms is very important in meeting the goals of storm water management discussed above.

Pollution Prevention Plan

The first term of importance is "storm water pollution prevention plan." As mentioned in Section 1.1, this manual is designed to help you to prepare and implement a Storm Water Pollution Prevention Plan. As you will learn in Chapter 2, Storm Water Pollution Prevention Plans consist of a series of steps and activities to, first, identify sources of pollution or contamination on your site, and, second, select and carry out actions which prevent or control the pollution of storm water discharges.

Best Management Practice

The other concept used throughout this manual is "Best Management Practice" or BMP. BMPs are measures or practices used to reduce the amount of pollution entering surface water, air, land, or ground waters. BMPs may take the form of a process, activity, or physical structure. Some BMPs are simple and can be put into place immediately, while others are more complicated and require extensive planning or space. They may be inexpensive or costly to implement. Although BMPs are used in many environmental programs, the BMPs presented in this manual are specifically designed to reduce or eliminate pollutants in storm water discharges. Chapter 2 describes the baseline BMP requirements of EPA's General Permit for storm water discharges associated with industrial activity. Chapters 3 and 4 describe numerous specific BMPs that will help you comply with these requirements.

1.5 GOALS OF STORM WATER MANAGEMENT

Federal, State, and local storm water management programs have a common goal:

To Improve Water Quality By Reducing the Pollutants Contained In Storm Water Discharges

Meeting this goal is a difficult challenge for many reasons. For example, the original sources of the pollutants transported in storm water can be diffuse or spread out over a wide area. So, small oil and grease spills at hundreds of different facilities within a single city can collectively represent a major pollution problem. In addition, the nature of storm water is such that the amount of pollutants that enter receiving waters will vary in accordance with the frequency, intensity and duration of rainfall and the nature of local drainage patterns. Considering the wide variety of types of industries in the United States and the wide range of materials and chemical compounds that are used as part of different industrial activities, a site-specific pollution prevention plan tailored for each facility is considered the most effective, flexible, and economically practical approach to achieve effective storm water management.

The pollution prevention plan approach required by EPA gives facilities flexibility to establish a site-specific storm water management program to meet Best Available Technology/Best Control Technology (BAT/BCT) standards required by the Clean Water Act instead of imposing numerical discharge limitations. Yet, the BMP framework established by the pollution prevention plan requirements must be fully implemented to meet these standards.

1.6 SUMMARY OF THE STORM WATER PROGRAM

Storm water discharges have been increasingly identified as a significant source of water pollution in numerous nationwide studies on water quality. To address this problem, the Clean Water Act Amendments of 1987 required EPA to publish regulations to control storm water discharges under NPDES. EPA published storm water regulations on November 16, 1990, which require certain dischargers of storm water to waters of the United States to apply for NPDES permits. "Waters of the United States" is generally defined as surface waters, including lakes, rivers, streams, wetlands, and coastal waters. NPDES storm water discharge permits will allow the States and EPA to track and monitor sources of storm water pollution. According to the November 16, 1990, final rule, facilities with a "storm water discharge associated with industrial activity" are required to apply for a storm water permit. EPA has defined this phrase in terms of 11 categories of industrial activity that include: (1) facilities subject to storm water effluent limitations guidelines, new source performance standards, or toxic pollutant effluent standards under 40 CFR Subchapter N; (2) "heavy" manufacturing facilities; (3) mining and oil and gas operations with "contaminated" storm water discharges; (4) hazardous waste treatment, storage, or disposal facilities; (5) landfills, land application sites, and open dumps; (6) recycling facilities; (7) steam electric generating facilities; (8) transportation facilities, including airports; (9) sewage treatment plants; (10) construction operations disturbing 5 or more acres*; and (11) other industrial facilities where materials are exposed to storm water*. Operators of industrial facilities that are Federally, State, or municipally owned or operated that meet the above description must also submit applications. If you have questions about whether or not your facility needs to seek permit coverage, contact the EPA Storm Water Hotline at (703) 821-4823.

Storm water discharges associated with industrial activity that reach waters of the United States through Municipal Separate Storm Sewer Systems (MS4s) are also required to obtain NPDES storm water permit coverage. Discharges of storm water to a combined sewer system or to a Publicly Owned Treatment Works (POTW) are excluded.

The storm water regulation presents three permit application options for storm water discharges associated with industrial activity. The first option is to submit an individual application consisting of Forms 1 and 2F. The second option is to participate in a group application. The third option is to file a Notice of Intent (NOI) to be covered under a general permit in accordance with the

*On June 4, 1992, the United States Court of Appeals for the Ninth Circuit remanded the exemptions for manufacturing facilities which do not have materials or activities exposed to storm water and for construction sites of less than five acres to the EPA for further rulemaking.

requirements of an issued general permit. Regardless of the permit application option a facility selects, the resulting storm water discharge permit will most likely contain a requirement to develop and implement a Storm Water Pollution Prevention Plan.

NPDES permits are issued by the State for States that have been delegated NPDES permitting authority or by EPA for States that have not been delegated NPDES permitting authority. Therefore, the specific EPA General Permit requirements discussed in this guidance manual apply only to facilities located in one of the 12 nondelegated States or Territories (Alaska; Arizona; Idaho; Louisiana; Maine; Massachusetts; New Hampshire; New Mexico; Oklahoma; South Dakota; Texas; the District of Columbia; Puerto Rico; Guam; American Samoa; Northern Mariana Islands; Trust Territory of the Pacific Islands; Indian lands in Alabama, California, Georgia, Kentucky, Michigan, Minnesota, Mississippi, Montana, North Carolina, North Dakota, New York, Nevada, South Carolina, Tennessee, Utah, Wisconsin, Wyoming; located within Federal facilities or Indian lands in Colorado and Washington; and located within Federal facilities in Delaware). EPA expects, however, that the Federal general permit will be used as a model by NPDES-authorized States, tailored to meet State-specific conditions. Even though storm water permit requirements will vary from State to State depending on water quality concerns and permitting priorities for the permitting authority, EPA expects that most NPDES storm water discharge permits will contain Storm Water Pollution Prevention Plan requirements similar to the requirements presented in this manual.

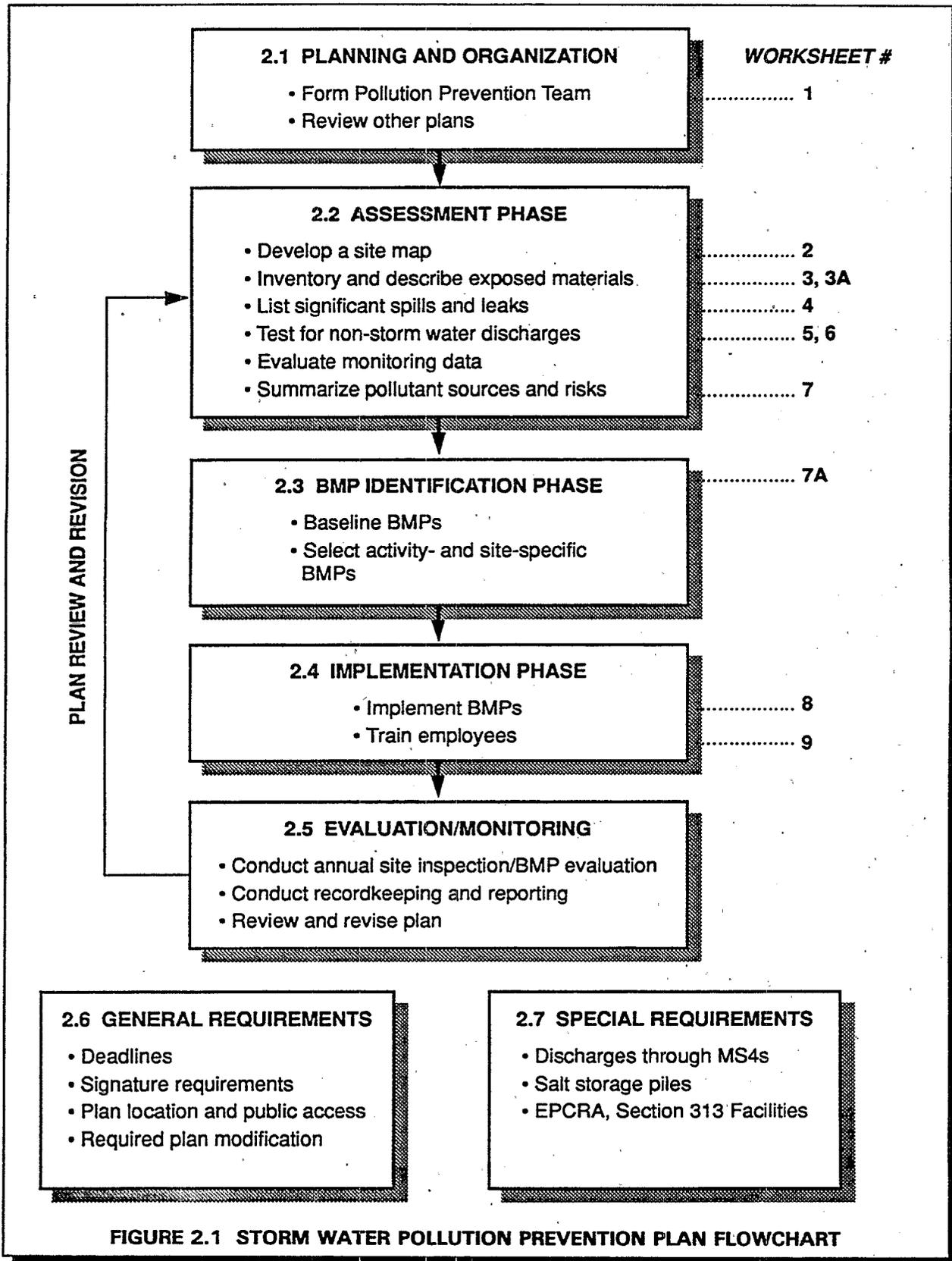
CHAPTER 2

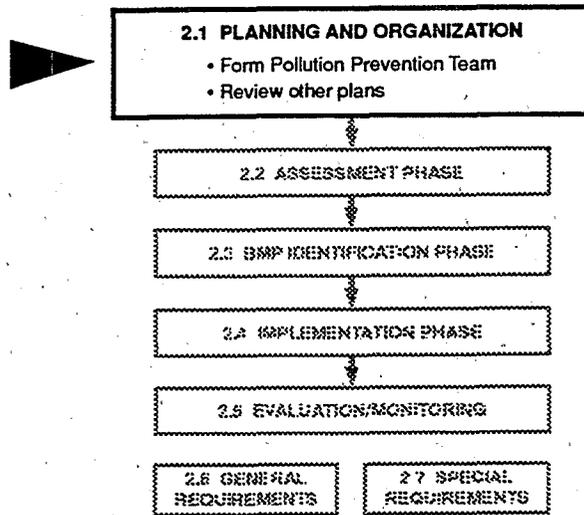
STORM WATER POLLUTION PREVENTION PLAN

Chapter 2 presents a step-by-step guide to help you develop a Storm Water Pollution Prevention Plan for your facility. Figure 2.1 is a flowchart showing each step involved in developing and implementing a successful plan. As shown in this flowchart, the steps have been grouped into five general phases, which are: (1) planning and organization; (2) assessment; (3) BMP identification; (4) implementation; and (5) evaluation/monitoring. In addition, Storm Water Pollution Prevention Plans also must address a number of general requirements, including developing a schedule or deadlines for the accomplishment of tasks, and an identification of signature authority, where required by Federal regulations. Some types of facilities will also have to meet other special requirements. For example, special requirements apply to facilities that discharge through municipal separate storm water systems as well as those facilities that are subject to reporting requirements under EPCRA, Section 313 for water priority chemicals.

Figure 2.1 also identifies a number of worksheets that can help walk you through the planning process. These worksheets are located at the end of Chapter 2. You can pull them out, photocopy them, and simply incorporate the completed forms in your plan.

The five planning phases, general requirements, and special requirements are discussed in turn in the remainder of this chapter. To help you follow along, a simplified version of the flowchart for the entire planning process is shown at the beginning of each section, with a highlighted box showing the particular phase that is being discussed. So, for example, you will find that the Planning and Organization Phase is highlighted on the flowchart at the top of page 2-3, signaling the beginning of our detailed discussion of this first step.





2.1 PLANNING AND ORGANIZATION PHASE

Before you start putting your Storm Water Pollution Prevention Plan together, there are two tasks to complete to make developing the plan easier. These steps are designed to help you organize your staff and make preliminary decisions:

- Decide who will be responsible for developing and implementing your Storm Water Pollution Prevention Plan
- Look at other existing environmental facility plans for consistency and overlap.

2.1.1 Who Will Develop and Implement Your Plan?

| EPA GENERAL PERMIT REQUIREMENTS |
|---|
| Pollution Prevention Team Part IV.D.1. |
| Each plan shall identify a specific individual or individuals within the facility organization as members of a storm water pollution prevention team that are responsible for developing the Storm Water Pollution Prevention Plan and assisting the facility or plant manager in its implementation, maintenance, and revision. The plan shall clearly identify the responsibilities of each team member. The activities and responsibilities of the team shall address all aspects of the facility's Storm Water Pollution Prevention Plan. |

What is the Purpose of Designating an Individual or a Team?

Designating a specific individual or team who will develop and implement your pollution prevention plan serves several purposes. Naming the individual or team members makes it clear that part of that person's job is to prevent storm water pollution. Identifying a specific individual also provides a point of contact for those outside the facility who may need to discuss aspects of the facility's pollution prevention plan (i.e., regulatory officials, etc.).

Where setting up a pollution prevention team is appropriate, it is important to identify the key people onsite who are most familiar with the facility and its operations, and to provide adequate structure and direction to the facility's entire storm water management program. The pollution prevention team concept is flexible and should be molded to conform to the resources and specific conditions of the facility. Specific activities of the pollution prevention team, the number of members, and their background and experience will vary for each facility.

Effective organization of the pollution prevention team is important in order for the team to be able to accomplish the task of developing and implementing a comprehensive Storm Water Pollution Prevention Plan. There are two important features in organizing a team of this nature: (1) selecting the right individuals to serve on the team; and (2) establishing good channels of communication.

What are the Roles and Responsibilities of the Designated Individual or Team?

The designated individual or team will be the driving force behind the development, implementation, maintenance, and revision of the facility's Storm Water Pollution Prevention Plan. One of the first tasks of those responsible is to define and agree upon a clear and reasonable set of goals for the facility's overall storm water management program. Where a team is involved, the responsibilities or duties of specific team members should be clearly defined.

Areas of responsibilities include initial site assessment, identification of pollutant sources and risks, decision making on appropriate BMPs, directing the actual implementation of the BMPs, and then, regular evaluations to measure the effectiveness of the plan. Details of these procedures are described in the latter part of this chapter.

To ensure that the Storm Water Pollution Prevention Plan remains effective, the person or team responsible for maintaining the pollution prevention plan must be aware of any changes that are made in plant operations to determine if any changes must be made.

While a designated individual or a pollution prevention team can be assigned the job of developing and implementing a Storm Water Pollution Prevention Plan, plant management is ultimately responsible for the implementation of the plan and for compliance with all applicable storm water requirements. Accordingly, the designated individual or team must have a clear line of communication with plant management to ensure that they are able to function in a cooperative partnership.

Who Should be on a Storm Water Pollution Prevention Team?

Any team, by definition, involves decision making and planning in a group setting. This allows for people with different ideas and areas of expertise to share knowledge and collectively figure out what works best for a particular facility. To broaden the base of involvement in the facility's storm water pollution prevention program, team members should represent all phases of the facility's operations.

For example, at a large facility, a team may be comprised of representatives from plant management, all aspects of production operations, engineering, waste handling and treatment (environmental department), and, if applicable, research and development. See Figure 2.2 for an illustration of an example team organizational chart.

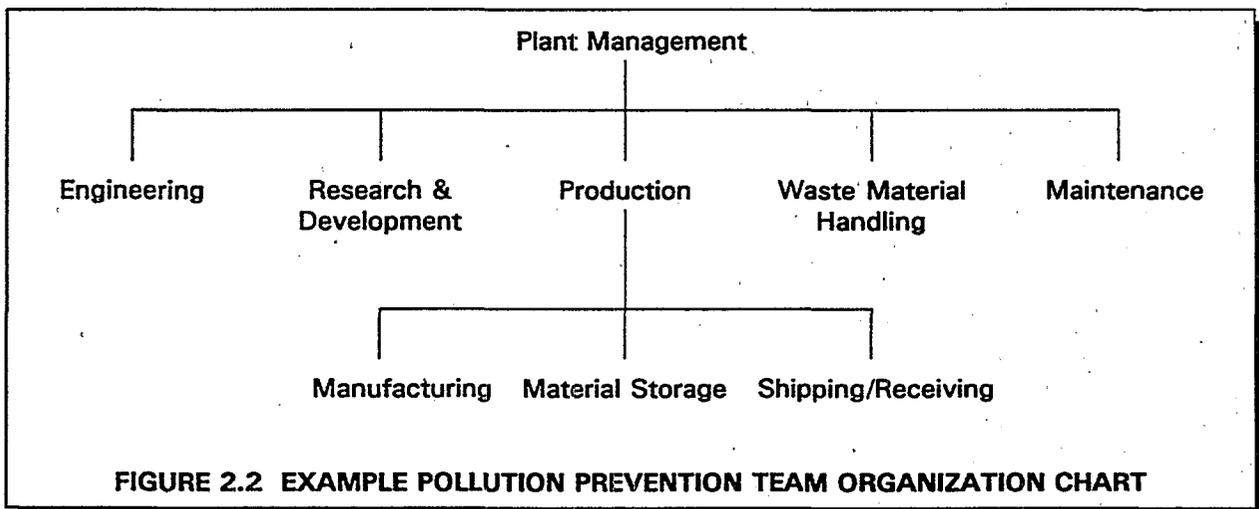


FIGURE 2.2 EXAMPLE POLLUTION PREVENTION TEAM ORGANIZATION CHART

Not all facilities will have or require all of these "team" positions. As mentioned above, team membership depends on the type of operations occurring at a facility. For example, a small trucking operation may find it appropriate to designate a single individual or a very small pollution prevention team with experience in key types of facility operations, such as vehicle maintenance, vehicle washing, fueling, and materials handling.

For a facility that has already designated a spill prevention and response team, the facility may use some of these personnel on the storm water pollution prevention team, thus overlapping the two groups to a certain extent. However, the roles and responsibilities of the pollution prevention team reach beyond the activities of a spill prevention and response team, and consequently, it would not be appropriate for a facility simply to substitute the spill response team for the pollution prevention team without clearly examining the roles and requirements related to storm water management (see Section 2.1.2).

Worksheet #1 (located at the end of Chapter 2) is an example of an appropriate form on which to list the team members. To complete this worksheet, list the pollution prevention team members by name, facility position (title), phone number, and include a brief description of each member's specific responsibilities. This list can be directly incorporated into the Storm Water Pollution Prevention Plan, but it should also be displayed or posted within the facility so that other plant employees are aware of who is responsible for storm water management.

EPCRA, Section 313 Facility Team Requirements

EPA's General Permit contains more specific pollution prevention team requirements for facilities subject to reporting under EPCRA, Section 313 for water priority chemicals [Part IV.D.7.b.(9)]. The team must designate a person who will be accountable for spill prevention at the facility and identify this person in the plan. The designated person is responsible for setting up necessary spill emergency procedures and reporting requirements to isolate, contain, and clean up spills and emergency releases of Section 313 water priority chemicals before a discharge can occur.

2.1.2 Building on Existing Environmental Management Plans

EPA GENERAL PERMIT REQUIREMENTS

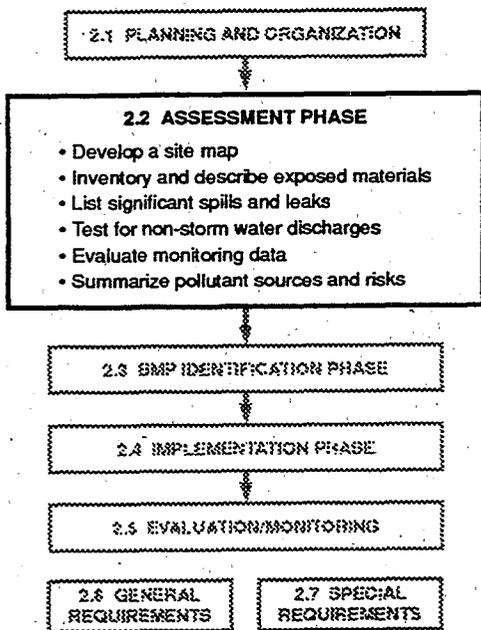
Consistency with Other Plans

Part IV.D.6.

Storm Water Pollution Prevention Plans may reflect requirements for Spill Prevention Control and Countermeasure (SPCC) plans developed for the facility under Section 311 of the Clean Water Act or BMP programs otherwise required by an NPDES permit for the facility as long as such requirement is incorporated into the Storm Water Pollution Prevention Plan.

Many industrial facilities may have already incorporated storm water management practices into day-to-day operations as a part of an environmental management plan required by other regulations. Potentially relevant elements of a number of different types of plans are listed in Appendix G at the end of this manual. The plans addressed include: the Preparedness, Prevention and Contingency Plan [40 Code of Federal Regulations (CFR) 264 and 265], the Spill Control and Countermeasures requirements (40 CFR 112), the National Pollutant Discharge Elimination System Toxic Organic Management Plan (40 CFR 413, 433, 469), and the Occupational Safety and Health Administration (OSHA) Emergency Action Plan (29 CFR 1910). It is the responsibility of the pollution prevention team to evaluate these other plans to determine which, if any, provisions may be incorporated into the Storm Water Pollution Prevention Plan.

In some cases, it may be possible to build on elements of these plans that are relevant to storm water pollution prevention. For example, if your facility already has in place an effective spill prevention and response plan, elements of that spill prevention strategy may be relevant to your approach for storm water pollution prevention. More specifically, lists of potential pollutants or constituents of concern may provide a starting point for your list of potential storm water pollutants. Although you should build on relevant portions of other environmental plans as appropriate, it is important to note that your Storm Water Pollution Prevention Plan must be a comprehensive, stand-alone document.



2.2 ASSESSMENT PHASE - DESCRIPTION OF POTENTIAL POLLUTANT SOURCES

After identifying who is responsible for developing and implementing your plan and organizing your planning process, you should proceed to this next step—a pollutant source assessment. This is where you take a look at your facility and site and determine what materials or practices are or may be a source of contaminants to the storm water running off your site. To complete this phase, you will:

- Assess the potential sources of storm water pollution at your facility
- Create a map of the facility site to locate pollutant sources and determine storm water management opportunities
- Conduct a material inventory
- Evaluate past spills and leaks
- Identify non-storm water discharges and illicit connections
- Collect or evaluate storm water quality data
- Summarize the findings of this assessment.

| EPA GENERAL PERMIT REQUIREMENTS |
|--|
| <p>Description of Potential Pollutant Sources</p> <p>Part IV.D.2.</p> <p>Each plan should provide a description of potential sources which may be reasonably expected to add significant amounts of pollutants to storm water discharges or which may result in the discharge of pollutants during dry weather from separate storm sewers draining the facility. Each plan shall identify all activities and significant materials which may potentially be significant pollutant sources.</p> |

This phase is designed to help you to target the most important pollutant sources for corrective and/or preventive action, thus using a "risk-based" approach to environmental protection. Details on how to complete this assessment are provided in the next six subsections of this chapter (see 2.2.1-2.2.6). These sections of the manual will help you discover areas at your facility that have the potential for contributing pollutants to storm water. Within each of the following sections, you will find helpful worksheets and suggestions for accomplishing a complete and accurate assessment of existing and potential problems. Each of the required components builds on the others; therefore, it is very important to perform each step thoroughly.

2.2.1 Developing a Site Map

| EPA GENERAL PERMIT REQUIREMENTS |
|---|
| <p style="text-align: center;">Site Drainage and Potential Pollutant Sources Part IV.D.2.a.(1).</p> <p>The facility site map must include:</p> <ul style="list-style-type: none">• An outline of the drainage area of each storm water outfall• Location of any existing structural control measures used to reduce pollutants in storm water runoff• Surface water bodies• Locations where significant materials are exposed to precipitation• Locations where major spills or leaks have occurred• Locations for each of the following activities (where exposed to storm water):<ul style="list-style-type: none">- Fueling stations- Vehicle and equipment maintenance and/or cleaning areas- Loading/unloading areas- Treatment, storage, or waste disposal areas- Liquid storage tanks- Processing areas- Storage areas. |

The facility site map is basically an illustration of the overall site and location, and should indicate property boundaries, buildings and operation or process areas, as well as provide information on drainage, storm water control structures, and receiving streams. Locating these features on the map will help you assess where potential storm water pollutants are located on your site, where they mix with storm water, and where storm water leaves your site. All of this information is essential in identifying the best opportunities for storm water pollution prevention or control. **Worksheet #2** (located at the end of Chapter 2) is designed to help you develop an appropriate and useful site map.

Figures 2.3 and 2.4 are good examples of site maps with different layers of information to help locate sources of pollution on your site. When properly drafted, your site map will be a very useful tool to assist in designing the proper pollution prevention controls, thereby preventing further degradation of water quality by reducing additional water pollution.

Outfalls and Drainage Areas

Once boundaries and facility structures have been shown on your site map, you should identify all of the storm water outfalls (also called "discharge points") on your site. A storm water outfall is the point where storm water enters a natural waterway or a separate storm sewer system. If your facility has its own storm water conveyance system, locate where the pipes or conveyances discharge to a stream, river, lake, or other water body. If your facility discharges to a municipal separate storm sewer system, your onsite drainage point into the system is an outfall. However, on many sites, storm water is simply collected in ditches. The discharge points may not be so obvious, particularly when it is not raining. In these cases, it may be necessary to inspect your site

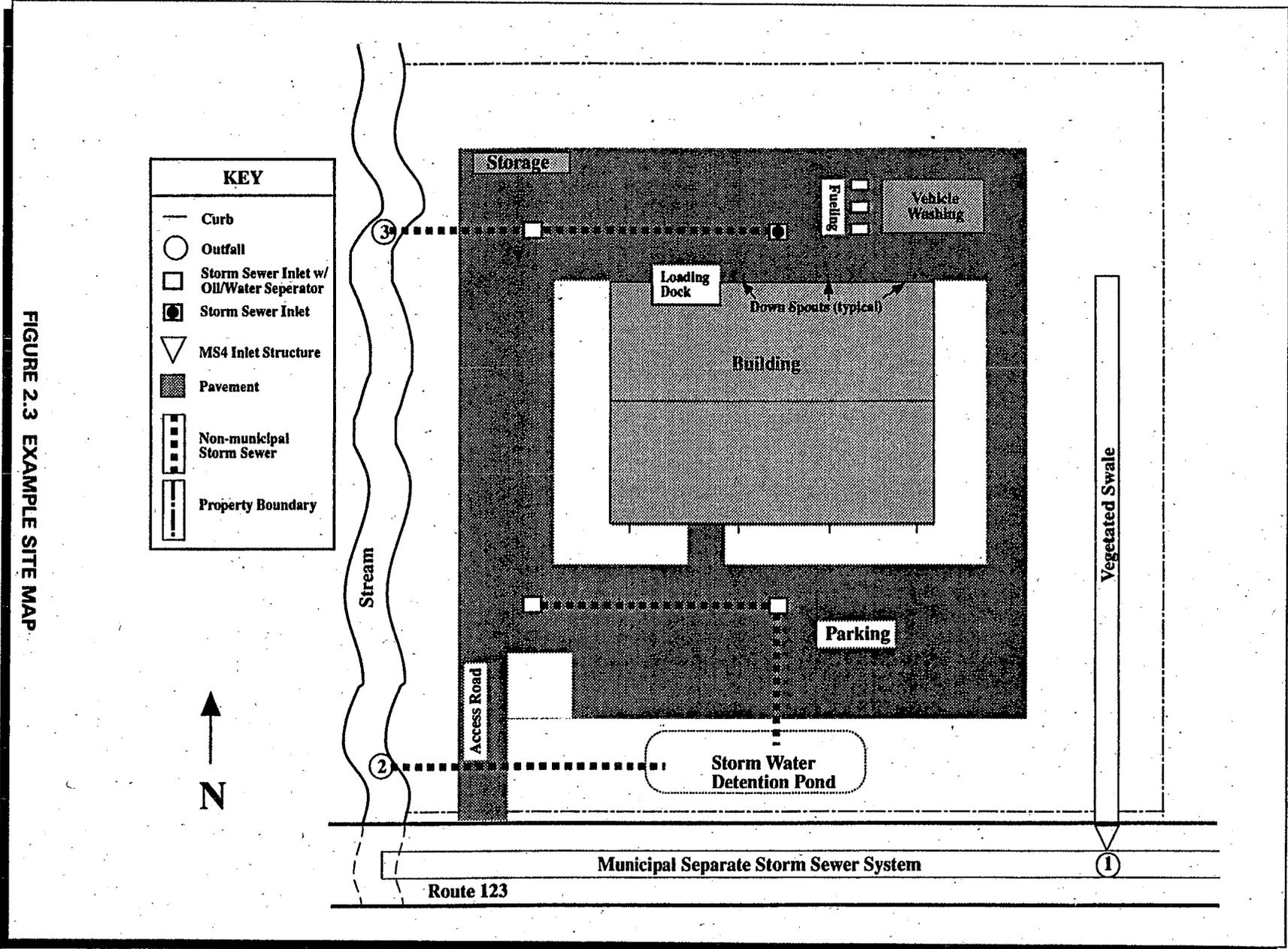
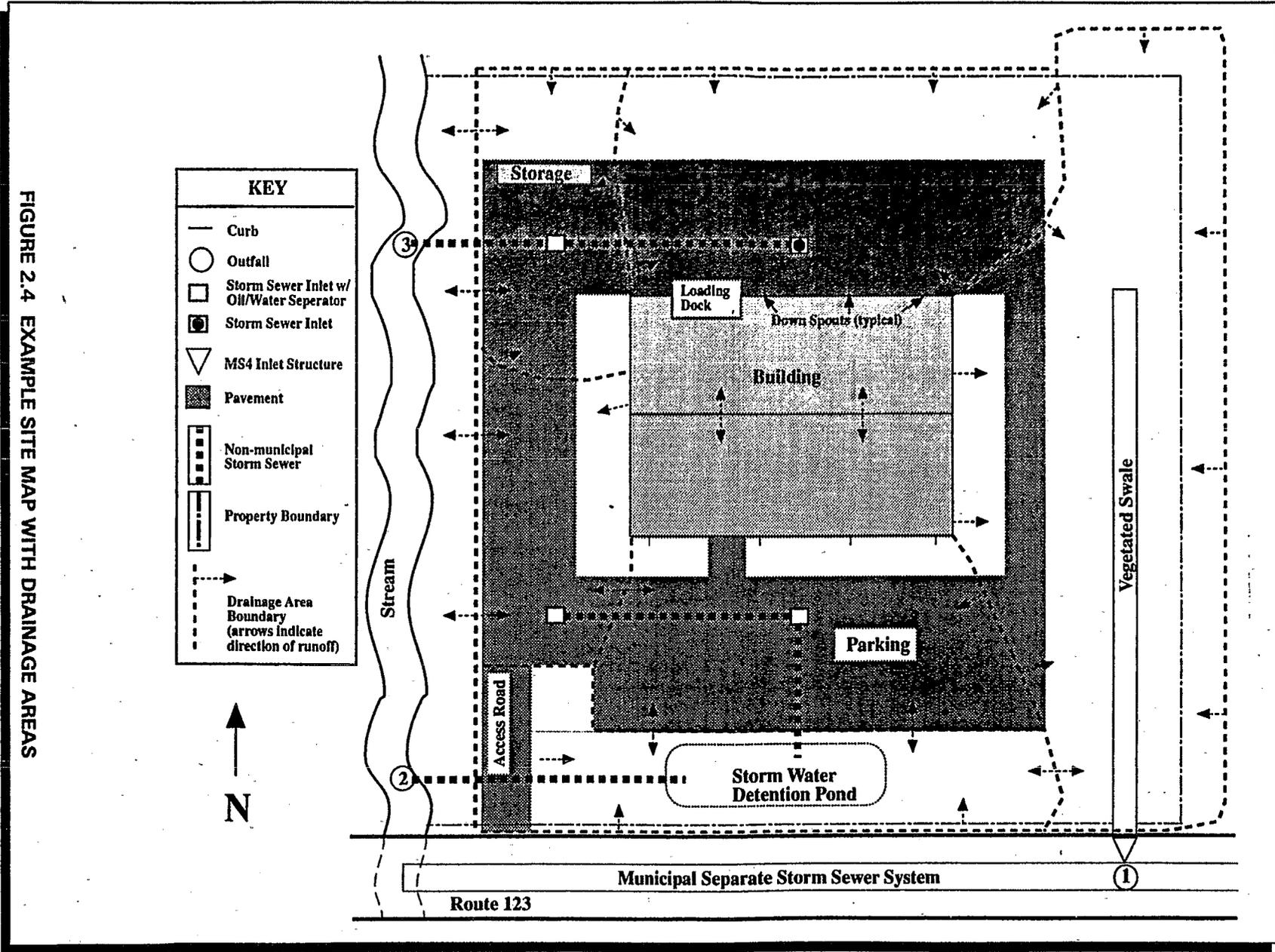


FIGURE 2.3 EXAMPLE SITE MAP





| KEY | |
|-----|--|
| — | Curb |
| ○ | Outfall |
| □ | Storm Sewer Inlet w/ Oil/Water Separator |
| ● | Storm Sewer Inlet |
| ▽ | MS4 Inlet Structure |
| ■ | Pavement |
| ⋯ | Non-municipal Storm Sewer |
| — | Property Boundary |
| ⋯ | Drainage Area Boundary (arrows indicate direction of runoff) |



FIGURE 2.4 EXAMPLE SITE MAP WITH DRAINAGE AREAS

particularly when it is not raining. In these cases, it may be necessary to inspect your site during a rain storm to identify your discharge points. Clearly label each outfall either with letters (A, B, C, etc.) or numbers (1, 2, 3, etc.) so that you can easily reference these discharge points in other sections of your Storm Water Pollution Prevention Plan.

Working back from the storm water outfalls you have identified, now determine the drainage areas for each outfall (see Figure 2.4). A topographic map can help with this task if one with the suitable scale is readily available. For larger facilities (greater than 25 acres), 7.5 minute topographic maps, available from the United States Geological Survey (USGS), probably have the level of detail necessary to determine site drainage patterns.

Maps may be purchased from local commercial dealers or directly from USGS information offices. Check your local yellow pages for commercial dealers. Topographic maps may also be purchased by mail. Standard topographic quadrangles cost \$2.50. You can order maps from the following locations:

USGS Map Sales
Box 25286
Denver, CO 80225

or

for Alaska maps:
USGS Map Sales
101 12th Ave., #12
Fairbanks, AK 99701

For smaller sites, examination of a topographic map may not reveal very much about the drainage patterns of the site. A simple alternative is to examine the contours of your site. A visual observation of flows or the use of small floatables or dyes in concentrated flows are simple methods to determine drainage patterns on your facility. Drainage patterns may be very obvious in some cases, such as drainage down a particular hill on the site. In areas where the site appears to be relatively flat, a rough study of storm water flow during a rain event should provide you with a sufficient sense of the flow patterns.

Structural Storm Water Controls

Other features to include on the site map are the locations and identification of any existing structural control measures already in place that are used to control or direct storm water runoff. A structural control measure is any physically constructed feature you have onsite that is used specifically to change the way that storm water flows or that is used to remove pollutants from storm water. Examples of structural controls include: retention/detention ponds, flow diversion structures (including ditches and culverts), vegetative swales, porous pavement, sediment traps, and any soil stabilization or erosion control practices. See Chapter 4 for a more complete description and illustrations of these structures. Each structure should be clearly identified on the site map, as illustrated in Figure 2.3.

Surface Waters

On the site map, you should label all surface water bodies on or next to the site. This includes any stream, river, lake, or other water body (see Figure 2.3 as an example). Each water body should be identified by name. If you do not know the name of the water body, you can check the USGS topographical maps discussed above for the legal name. Your municipal government may also have municipal maps that identify small streams by name. If your storm water runoff flows into a small, unnamed tributary, the name of the downstream water body will be sufficient.

Potential Pollutant Sources

To develop a useful site map for your facility's Storm Water Pollution Prevention Plan, you must also indicate other items on the map so that you understand what activities are taking place in each drainage area, and therefore, what types of pollutants may be present in storm water from these areas. These features include:

- Topography of site (discussed above)
- Location of exposed significant materials (see Section 2.2.2)
- Locations of past spills and leaks (see Section 2.2.3)
- High-risk waste generating areas and activities common on industrial sites, such as:
 - Fueling stations
 - Vehicle and equipment maintenance
 - Vehicle and equipment washing
 - Loading and unloading areas
 - Above-ground liquid storage tanks
 - Industrial waste management areas and outside manufacturing
 - Outside storage of raw materials, by-products, or finished products.

You will notice that specific BMPs may be applied to control the amount of pollutants in storm water discharges from these areas (see Chapter 3). Now is the time to determine if any of these activities take place onsite, and in which drainage areas they take place.

| EPA GENERAL PERMIT REQUIREMENTS |
|--|
| <p style="text-align: center;">Types of Pollutants and Flow Direction Part IV.D.2.a.(2).</p> <p>For each area of the facility that generates storm water discharges associated with industrial activity with a reasonable potential for containing significant amounts of pollutants, include a prediction of the direction of flow and identify the types of pollutants which are likely to be present in storm water discharges associated with industrial activity. Factors to consider include the toxicity of the chemical; quantity of chemicals used, produced, or discharged; the likelihood of contact with storm water; and the history of significant leaks or spills of toxic or hazardous pollutants. Flows with a significant potential for causing erosion shall be identified.</p> |

2.2.2 Material Inventory

| EPA GENERAL PERMIT REQUIREMENTS |
|--|
| <p>Inventory of Exposed Materials Part IV.D.2.b.</p> |
| <p>Conduct an inventory of materials that may be exposed to storm water at your site, and include a narrative description of:</p> <ul style="list-style-type: none"> • Significant materials that have been handled, treated, stored, or disposed in a manner to allow exposure to storm water between the time of three years prior to the date of permit issuance and the present • Method(s) and location of onsite storage or disposal • Materials management practices employed to minimize contact of these materials with storm water runoff between the time of three years prior to the date of the issuance of the permit and the present • Existing structural and nonstructural control measures to reduce pollutants in storm water runoff, including their locations • Any treatment of storm water runoff. |

The next step in the Assessment Phase is to conduct a material inventory at your site, specifically looking for materials that have been exposed to storm water and measures you have taken to prevent the contact of these materials with storm water. Maintaining an up-to-date material inventory is an efficient way to identify what materials are handled onsite and which may contribute to storm water contamination problems. As discussed above, these potential pollutant sources should be identified on your facility's site map.

Worksheet #3 (located at the end of Chapter 2) will help guide you through the process of conducting a material inventory for your Storm Water Pollution Prevention Plan. Although an inventory of all materials (exposed and not exposed) is required as part of EPA's General Permits, conducting such an inventory is a good first step in compiling a list of exposed materials. If any of the significant materials on your site have been exposed to storm water in the three years prior to the effective date of your permit, fill out **Worksheet #3A** and include it in your plan.

Inventory of Exposed Significant Materials

"Significant materials," as defined in 40 CFR 122.26(b)(12), are substances related to industrial activities such as process chemicals, raw materials, fuels, pesticides, and fertilizers (see Glossary in Appendix B for exact definition). When these substances are exposed to storm water runoff, they may be carried to a receiving stream with the storm water flow. Therefore, identification of these materials helps to determine where a potential for contamination exists and is the first step in identifying appropriate BMPs to address this contamination potential.

To inventory the materials on your site, inspect your site carefully. You may wish to use the site checklist (page 2-14) to help you identify exposed materials. Focus on areas where you store, process, transport or transfer any materials used or produced during your industrial processes. Check any storage tanks, pipes or pumping areas and note any leaks or spills. Observe any loading

or unloading operations and indicate whether any industrial materials are exposed to storm water during those processes. Look at any unsealed dumpsters or disposal units/areas where you deposit wastes from your industrial activities and document instances where waste materials are exposed to rain. Also pay attention to material handling equipment, including everything from vehicles to pallets, where raw and waste materials from your industrial activities are exposed. Finally, consider areas such as the roof where particles are emitted from air vents and are likely to fall within your drainage areas.

| Site Checklist | |
|--------------------------|---|
| <input type="checkbox"/> | Does your facility show signs of poor housekeeping (cluttered walkways, unswept floors, uncovered materials, etc.)? |
| <input type="checkbox"/> | Are there spots, pools, puddles, or other traces of oil, grease, or other chemicals on the ground? |
| <input type="checkbox"/> | Is there discoloration, residue, or corrosion on the roof or around vents or pipes that ventilate or drain work areas? |
| <input type="checkbox"/> | Do you see leaking equipment, pipes, containers, or lines? |
| <input type="checkbox"/> | Are there areas where absorbent materials (kitty litter, saw dust, etc.) are regularly used? |
| <input type="checkbox"/> | Do you notice signs such as smoke, dirt, or fumes that indicate material losses? |
| <input type="checkbox"/> | Do you smell strange odors, or experience eye, nose, or throat irritation when you first enter the work area? These are indications of equipment leaks. |
| <input type="checkbox"/> | Do storage containers show signs of corrosion or leaks? |
| <input type="checkbox"/> | Are there open containers, stacked drums, shelving too small to properly handle inventory, or other indications of poor storage procedures? |
| <input type="checkbox"/> | Are containers properly labeled? |

These are some basic guidelines meant to help you determine what kinds of things to look out for. This list does not necessarily cover every possible source of pollutants. As the site operator, you are responsible for knowing the particular concerns associated with your activity. Be as detailed as you can in your description of the significant materials exposed at your facility. Discuss what you found in your assessment, the amounts present and their location. Update this inventory whenever new, significant materials are introduced and exposed onsite so that your management practices can be modified to suit any changes.

Next, you should give closer scrutiny to areas where you store or dispose of industrial materials. Inspect your various containers carefully and note whether there are any openings, holes or leaks that allow storm water to contact significant materials in those containers.

Existing Management Measures and Treatment of Storm Water Runoff

Now that you have described the potential pollutant sources in storm water runoff from your site, you should describe what management practices you currently use. Management practices can be as simple as scheduled sweeping of the material transfer area. In this section of your plan you must describe both structural and nonstructural management practices. Structural management

practices are those practices that entail construction of manmade structures such as berms, detention ponds, or grassed swales, whereas nonstructural management practices involve regularly scheduled actions (such as sweeping, inspections, or improved materials handling and management practices).

Remember that the purpose of BMPs is to keep the pollutants out of storm water runoff by reducing material exposure to storm water, directing the storm water away from contaminated areas, or reducing the volume of potentially polluting materials on the site.

Finally, you must describe any treatment that you provide for the storm water discharges from your site. The treatment of storm water is often accomplished through holding in a detention pond which allows for settling of inorganic solids and partial removal of organic contaminants. In the case of detention ponds, you should describe the size and average depth of each pond on your site (storage volume). You should also provide any design criteria (i.e., design flow rates, etc.) for the pond that may be available to you from engineering design reports or diagrams. Your site may also direct some of your storm water into your process water treatment system. If so, you should identify what type of treatment is provided, and whether this is allowed under your NPDES or other discharge permit. In any case, be sure to specify areas from which the treated storm water drains.

2.2.3 Identifying Past Spills and Leaks

| EPA GENERAL PERMIT REQUIREMENTS |
|--|
| Spills and Leaks Part IV.D.2.c. |
| Include a list of significant spills and significant leaks of toxic or hazardous pollutants that occurred at areas that are exposed to precipitation or that otherwise drain to a storm water conveyance at the facility after the date of three years prior to the effective date of this permit. Such list shall be updated as appropriate during the term of this permit. |

The next component of the assessment phase of your pollution prevention plan is a list of significant spills and significant leaks of toxic or hazardous materials that have occurred at your facility. This list provides information on potential sources of storm water contamination. The first question that comes to mind is "What is a significant spill or leak?"

EPA has defined "significant spills" to include releases within a 24-hour period of hazardous substances in excess of reportable quantities under Section 311 of the Clean Water Act and Section 102 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Reportable quantities are set amounts of substances in pounds, gallons, or other units and are listed in 40 CFR Part 117 and 40 CFR Part 302. This list is included as Appendix H in this manual. If your facility releases these listed hazardous substances to the environment in excess of these amounts, you are required to notify the National Response Center at (800) 424-8802 as soon as possible. Releases are defined to include any spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing into the environment.

Worksheet #4 (located at the end of Chapter 2) can help you organize this list of leaks and spills. The areas on your site where significant leaks or spills have occurred are areas on which you should focus very closely when selecting activity-specific or site-specific BMPs.

If several of these events have occurred at your facility, pay special attention to Section 2.3.1, which discusses spill prevention and response procedures. Adequate spill prevention and response

procedures are one of the BMPs that should be included in your pollution prevention plan. Using the proper procedures will reduce the likelihood of spills or releases in the future, thus reducing the opportunity for spilled pollutants to come into contact with storm water.

The above list of significant leaks and spills, together with the other information gathered to identify pollutants and sources, provides the necessary focus for the BMP Identification Phase of your facility's Storm Water Pollution Prevention Plan. This information is used to target pollution prevention activities such as preventive maintenance, good housekeeping, spill prevention and response procedures, employee training, and storm water management controls such as covering, flow diversion, erosion control and treatment that ultimately will reduce pollutant loadings in storm water discharges.

2.2.4 Identifying Non-Storm Water Discharges

| EPA GENERAL PERMIT REQUIREMENTS |
|--|
| <p style="text-align: center;">Non-Storm Water Discharges Part IV.D.3.g.(1).</p> <p>The plan must include a certification that all storm water outfalls have been tested or evaluated for the presence of non-storm water discharges. The certification shall include:</p> <ul style="list-style-type: none">• Identification of potential non-storm water discharges• A description of the results of any test and/or evaluation for the presence of non-storm water discharges• The evaluation criteria or test method used• The date of testing and/or evaluation• The onsite drainage points that were directly observed during the test and/or evaluation. <p>This certification shall be signed in accordance with Section 2.6.2 in this manual and must be included in your Storm Water Pollution Prevention Plan. An example certification form is provided as Worksheet #5.</p> <p>If this certification is not feasible because you do not have access to an outfall, manhole, or other point of access to the final storm water discharge point(s), you should describe why the certification was infeasible. You also must notify the permitting authority by October 1, 1993 [or 180 days after submitting the Notice of Intent (NOI) for facilities that begin industrial activities after October 1, 1992], of any potential sources of non-storm water discharges to the storm water discharge and why you could not perform the test for non-storm water discharges. This certification must be signed in accordance with Section 2.6.2 of this manual and submitted to the permitting authority. An example Failure to Certify form is provided as Worksheet #6.</p> |

Examples of non-storm water discharges include any water used directly in the manufacturing process (process water), air conditioner condensate, non-contact cooling water, vehicle wash water, or sanitary wastes. Connections of non-storm water discharges to a storm water collection system are common yet are often unidentified. Those types of discharges are significant sources of water quality problems. Unless permitted by an NPDES permit, such discharges are illegal. If such connections are discovered, disconnect them or submit an NPDES permit application (Form 2C

for process wastewater or 2E for nonprocess wastewater) to your permitting authority. Such interconnections must be disconnected or covered by an NPDES permit.

To check for non-storm water discharges, you may elect to use one of four common dry weather tests described below and in more detail in Appendix F: (1) visual inspection; (2) plant schematic review; and (3) dye testing.

Visual Inspection

The easiest method for detecting non-storm water connections into the storm water collection system is simply to observe all discharge points during dry weather. Inspect each discharge point on three separate occasions. As a rule, the discharge point should be dry during a period of extended dry weather since a storm water collection system should only collect storm water. Keep in mind, however, that drainage of a particular rain event can continue for three days or more after the rain has stopped. In addition, infiltration of ground water into the underground collection system is also common. To be sure about the source of any flow during dry weather, you may need to perform one of the additional tests described below.

Sewer Map

A review of a plant schematic is another simple way to determine if there are any interconnections into the onsite storm water collection system. A sewer map or plant schematic is a map of pipes and drainage systems used to carry process wastewater, non-contact cooling water, air conditioner condensate, and sanitary wastes (bathrooms, sinks, etc.). A common problem, however, is that sites often do not have accurate, up-to-date schematics. If you do have an accurate and reliable plant schematic, you can simply examine the pathways of the different water circuits listed above. Be sure also to investigate where the floor drains discharge. These are commonly connected to the storm sewer system, especially in older buildings.

Dye Testing

Another method for detecting improper connections to the storm water collection system is dye testing. A dye test can be performed by simply releasing a dye into either your sanitary or process wastewater system and examining the discharge points from the storm water collection system for discoloration. A detailed description of the equipment needed and proper procedures for a dye test is included in Appendix F.

Non-Storm Water Discharges

As noted above, unless covered by an NPDES permit, non-storm water discharges are illegal. Generally, non-storm water discharges are issued individual NPDES permits based on application Form 2C (for process wastewater) or Form 2E (for nonprocess wastewater). However, EPA's General Permit authorizes the following types of non-storm water discharges:

- Discharges from fire fighting activities
- Fire hydrant flushings
- Potable water sources including waterline flushings
- Irrigation drainage

- Lawn watering
- Uncontaminated ground water
- Foundation or footing drains where flows are not contaminated with process materials
- Discharges from springs
- Routine exterior building washdown which does not use detergents or other compounds
- Pavement wash waters where spills or leaks of toxic or hazardous materials have not occurred and where detergents are not used
- Air conditioning condensate.

Be sure to examine your facility's storm water permit to determine whether it authorizes any of these or other non-storm water discharges. If your permit does not authorize non-storm water discharges occurring at your facility, you should contact your permitting authority or the Storm Water Hotline for more information about how to address these discharges.

EPA GENERAL PERMIT REQUIREMENTS

Non-Storm Water Discharges

Part IV.D.3.g.(2)

Except for flows from fire fighting activities, sources of non-storm water that are authorized by this permit must be identified in the plan. The plan shall identify and ensure the implementation of appropriate pollution prevention measures for the non-storm water component of the discharge.

Generally, except for flows from fire fighting activities, all non-storm water connections that are identified and that are authorized by your storm water discharge permit should be identified in the Storm Water Pollution Prevention Plan. Where necessary to minimize pollutants in these discharges, pollution prevention measures should be adopted and implemented. The pollution potential from these sources can be significantly reduced where a conscious effort is taken to control them.

2.2.5 Storm Water Monitoring Data

| EPA GENERAL PERMIT REQUIREMENTS |
|--|
| Sampling Data Part IV.D.2.d. |
| Include a summary of any existing discharge sampling data describing pollutants in storm water discharges from the facility and a summary of sampling data collected during the term of this permit. |

Storm water sampling data provide information that describes the quality of storm water discharges. These data are valuable because they indicate the potential environmental risk of the discharge by identifying the types and amounts of pollutants present. In addition, these data can be used to identify potential sources of storm water pollution.

During the site assessment phase, permittees should collect and summarize any storm water sampling data that were collected in the past. Historical storm water monitoring data may be very useful in locating areas which have previously contributed pollutants to storm water discharges and identifying what the problem pollutants are. In your summary of these data, describe the sample collection procedures used. Be sure to cross-reference the particular storm water outfall sampled to one of the outfalls designated on your site map.

Although some permittees may not have to conduct storm water sampling under the permit that is issued to that facility, incorporation of these data into the Storm Water Pollution Prevention Plan as it is collected will provide a basis for evaluating the effectiveness of the plan. Under EPA's General Permit, certain classes of facilities are required to conduct storm water sampling either annually or semiannually throughout the term of the permit. Appendix J contains a table summarizing these sampling requirements, including the parameters for which analysis is required and the sampling frequency. State-issued storm water general permits may include similar provisions. Generally, where sampling is required, facilities must collect and analyze grab and composite samples in accordance with the protocol established in 40 CFR Part 136. EPA has published a guidance manual addressing storm water sampling requirements and procedures for NPDES storm water discharge permit applications. Although directed toward application requirements, the guidance manual contains information that would be of assistance to facilities required to sample under a storm water general permit. To obtain a copy of the manual, call the Storm Water Hotline at (703) 821-4823.

2.2.6 Assessment Summary

| EPA GENERAL PERMIT REQUIREMENTS |
|---|
| <p>Risk Identification and Summary of Potential Pollutant Sources Part IV.D.2.e.</p> <p>Include in your plan a narrative description of the potential pollutant sources and identify any pollutant of concern that may be generated by the following activities at your facility:</p> <ul style="list-style-type: none">• Loading and unloading operations• Outdoor storage activities• Outdoor manufacturing or processing activities• Significant dust or particulate generating activities• Onsite waste disposal practices. |

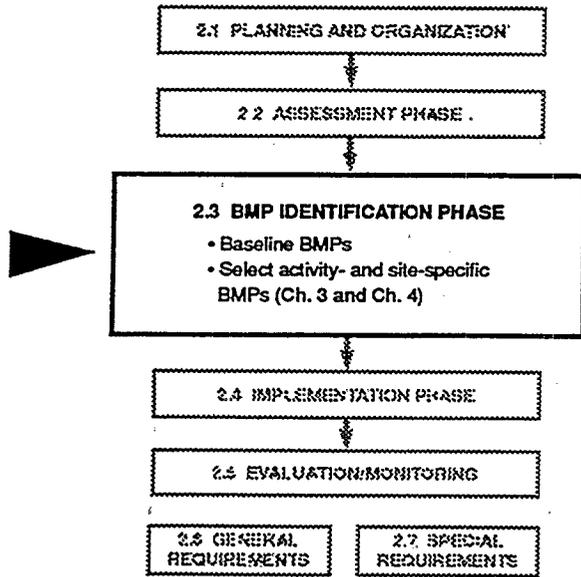
Once you have completed the above steps in your pollutant source assessment, you should have enough information to determine which areas, activities or materials may contribute pollutants to storm water runoff from your site. With this information, you can select the most appropriate BMPs to prevent or control pollutants from these areas.

The following paragraph is an example of how you can analyze the information you have gathered and start to figure out what you can do to correct these problems:

In a particular drainage area, you have a vehicle maintenance facility area where oil filters are stored outdoors. You found that no material management practices were currently being used to protect the used filters from contact with storm water. You would then suspect that the storm water draining from that area would most likely contain a significant amount of oil and grease. Therefore, you have concluded that you need to do something to reduce the possibility of oil and grease mixing with storm water.

EPA's General Permit requires this type of narrative description summarizing any potential source of storm water pollutants, and what types of pollutants have already been or may be found in storm water runoff from the site.

Worksheet #7 (located at the end of Chapter 2) will help you organize the pollutant sources that you identified during the site assessment phase, relate them to management practices that you already have in place, and list potential new BMP options to address remaining pollutant sources.



2.3 BMP IDENTIFICATION PHASE

Once you have identified and assessed potential and existing sources of contamination to storm water at your facility, the next step is to select the proper measures or BMPs that will eliminate or reduce pollutant loadings in storm water discharges from your facility site. Specifically, your plan design will include the following BMPs:

- Good housekeeping
- Preventive maintenance
- Visual inspections
- Spill prevention and response
- Sediment and erosion control
- Management of runoff
- Employee training
- Recordkeeping and reporting
- Other BMPs as appropriate

BMPs are measures used to prevent or mitigate pollution from any type of activity. BMPs are a very broad class of measures and may include processes, procedures, schedules of activities, prohibitions on practices, and other management practices to prevent or reduce water pollution. In essence, they are anything a plant manager, department foreman, environmental specialist, consultant or employee may identify as a method, short of actual treatment, to curb water pollution. They may be inexpensive or costly. BMPs can be just about anything that "does the job" of preventing toxic or hazardous substances from entering the environment.

The purpose of this section is to describe the "baseline" BMPs that you must include in your facility's storm water pollution prevention program and offer some guidelines about how to select more "advanced" BMPs that are tailored to the specific pollutant sources on your particular site. With this information, you should be able to design a storm water management program that best addresses any problems with runoff from your facility's site.

2.3.1 Baseline Best Management Practices

| EPA GENERAL PERMIT REQUIREMENTS |
|---|
| <p>Measures and Controls Part IV.D.3.</p> <p>Each facility covered by this permit shall develop a description of storm water management controls appropriate for the facility and implement such controls. The appropriateness and priorities of controls in a plan shall reflect identified potential sources of pollutants at the facility. The description of storm water management controls shall address the following minimum components, including a schedule for implementing such controls:</p> <ul style="list-style-type: none">• Good Housekeeping• Preventive Maintenance• Visual Inspections• Spill Prevention and Response• Sediment and Erosion Control• Management of Runoff• Employee Training (see Section 2.4.2)• Recordkeeping and Reporting (see Section 2.5.2) |

"Baseline" BMPs are practices that are inexpensive, relatively simple, and applicable to a wide variety of industries and activities. Most industrial facilities already have these measures in place for product loss prevention, accident and fire prevention, worker health and safety, or to comply with other environmental regulations. The purpose of this section is to highlight how these common practices can be improved and tailored to prevent storm water pollution. EPA's Storm Water Program is emphasizing these generic measures because they can be effective, are cost-effective, and because they emphasize prevention over treatment.

Industrial facilities must implement, at a minimum, the above-listed eight baseline BMPs, where appropriate. How each of these BMPs can prevent storm water pollution is described in detail below.

Worksheet #7a (located at the end of Chapter 2) is designed to help you list the specific activities or practices that you select to include in your plan for each of the baseline BMPs.

Good Housekeeping

EPA GENERAL PERMIT REQUIREMENTS

Good Housekeeping

Part IV.D.3.a.

Good housekeeping requires the maintenance of areas which may contribute pollutants to storm water discharges in a clean, orderly manner.

Good housekeeping practices are designed to maintain a clean and orderly work environment. Often the most effective first step towards preventing pollution in storm water from industrial sites simply involves using good common sense to improve the facility's basic housekeeping methods. Poor housekeeping can result in more waste being generated than necessary and an increased potential for storm water contamination. A clean and orderly work area reduces the possibility of accidental spills caused by mishandling of chemicals and equipment and should reduce safety hazards to plant personnel. Well maintained material and chemical storage areas will reduce the possibility of storm water mixing with pollutants.

There are some simple procedures a facility can use to promote good housekeeping, including improved operation and maintenance of industrial machinery and processes, material storage practices, material inventory controls, routine and regular clean-up schedules, maintaining well organized work areas, and educational programs for employees about all of these practices. The following sections describe these good housekeeping procedures and provide a checklist that you can use to evaluate and improve your facility's storm water pollution prevention program.

Operation and Maintenance

These practices ensure that processes and equipment are working well. Improved operation and maintenance practices are easy to implement. Here are a few examples of basic operation and maintenance BMPs that should be incorporated in your good housekeeping program:

- Maintain dry and clean floors and ground surfaces by using brooms, shovels, vacuum cleaners, or cleaning machines
- Regularly pickup and dispose of garbage and waste material
- Make sure equipment is working properly (see Section 2.3.4 on preventive maintenance)
- Routinely inspect for leaks or conditions that could lead to discharges of chemicals or contact of storm water with raw materials, intermediate materials, waste materials, or products (see Visual Inspection BMP below)
- Ensure that spill cleanup procedures are understood by employees (see Spill Prevention and Response BMP below).

Material Storage Practices

Improper storage can result in the release of materials and chemicals that can cause storm water runoff pollution. Proper storage techniques include:

- Providing adequate aisle space to facilitate material transfer and easy access for inspections
- Storing containers, drums, and bags away from direct traffic routes to prevent accidental spills (see Spill Prevention and Response BMP below)
- Stacking containers according to manufacturers' instructions to avoid damaging the containers from improper weight distribution
- Storing containers on pallets or similar devices to prevent corrosion of the containers which can result when containers come in contact with moisture on the ground
- Assigning the responsibility of hazardous material inventory to a limited number of people who are trained to handle hazardous materials.

Material Inventory Procedures

Keeping an up-to-date inventory of all materials (hazardous and non-hazardous) present on your site will help to keep material costs down caused by overstocking, track how materials are stored and handled onsite, and identify which materials and activities pose the most risk to the environment. The following instructions explain the basic steps to completing a material inventory. **Worksheets #3 and 3A** provide an example of the types of information you should collect while conducting the inventory.

- **Identify all chemical substances present in the workplace.** Walk through the facility and review the purchase orders for the previous year. List all of the chemical substances used in the workplace, and then obtain the Material Safety Data Sheet (MSDS) for each.
- **Label all containers** to show the name and type of substance, stock number, expiration date, health hazards, suggestions for handling, and first aid information. This information can usually be found on the MSDS. Unlabeled chemicals and chemicals with deteriorated labels are often disposed of unnecessarily or improperly.
- **Clearly mark on the inventory hazardous materials** that require special handling, storage, use, and disposal considerations.

Improved material tracking and inventory practices, such as instituting a shelf-life program, can reduce the waste that results from overstocking and the disposal of out-dated materials. Careful tracking of all materials ordered may also result in more efficient materials use.

Decisions on the amount of hazardous materials the facility stores should include an evaluation of your emergency control systems. Ensure that storage areas are designed to contain spills.

Employee Participation

Frequent and proper training of employees in good housekeeping techniques reduces the possibility that the chemicals or equipment will be mishandled. Motivating employees to reduce waste generation is another important pollution prevention technique. Section 2.4.2 provides more information on employee training programs. Here are some suggestions for involving employees in good housekeeping practices:

- Incorporate information sessions on good housekeeping practices into the facility's employee training program
- Discuss good housekeeping at employee meetings
- Publicize pollution prevention concepts through posters
- Post bulletin boards with updated good housekeeping procedures, tips and reminders.

Good Housekeeping Checklist

- Is good housekeeping included in the storm water pollution prevention program?
- Are outside areas kept in a neat and orderly condition?
- Is there evidence of drips or leaks from equipment or machinery onsite?
- Is the facility orderly and neat? Is there adequate space in work areas?
- Is garbage removed regularly?
- Are walkways and passageways easily accessible, safe, and free of protruding objects, materials or equipment?
- Is there evidence of dust on the ground from industrial operations or processes?
- Are cleanup procedures used for spilled solids?
- Is good housekeeping included in the employee program?
- Are good housekeeping procedures and reminders posted in appropriate locations around the workplace?
- Are there regular housekeeping inspections?

Preventive Maintenance

EPA GENERAL PERMIT REQUIREMENTS

Preventive Maintenance

Part IV.D.3.b.

Your preventive maintenance program must include:

- Timely inspection and maintenance of storm water management devices (e.g., cleaning oil/water separators, catch basins)
- Inspection and testing of facility equipment and systems to uncover conditions that could cause breakdowns or failures resulting in discharges of pollutants to surface waters
- Proper maintenance of facility equipment and systems.

Most plants already have preventive maintenance programs that provide some degree of environmental protection. The program you undertake as part of the Storm Water Pollution Prevention Plan should not just duplicate previous efforts, but should expand the current preventive maintenance programs to include storm water considerations, especially the upkeep and maintenance of storm water management devices. The pollution prevention team should evaluate the existing plant preventive maintenance program and recommend any necessary changes.

Preventive maintenance involves the regular inspection and testing of plant equipment and operational systems (see Visual Inspections description below). These inspections should uncover conditions such as cracks or slow leaks which could cause breakdowns or failures that result in discharges of chemicals to storm sewers and surface waters. The program should prevent breakdowns and failures by adjustment, repair or replacement of equipment. An effective preventive maintenance program should therefore include the following elements:

- Identification of equipment, systems, and facility areas that should be inspected
- Schedule for periodic inspections or tests of these equipment and systems
- Appropriate and timely adjustment, repair or replacement of equipment and systems
- Maintenance of complete records on inspections, equipment, and systems.

Identification of Equipment to Inspect

The first step is to identify which systems or equipment may malfunction and cause spills, leaks, or other situations that could lead to storm water runoff contamination. Look back at what sources of potential storm water contamination were identified during the pollutant source assessment phase. The following list identifies some types of equipment to include in your preventive maintenance inspection and testing program:

| Equipment to Inspect |
|---|
| <ul style="list-style-type: none">• Pipes• Pumps• Storage tanks and bins• Pressure vessels• Pressure release valves• Process and material handling equipment• Storm water management devices (oil/water separators, catch basins, or other structural or treatment BMPs). |

Schedule Routine Preventive Maintenance Inspections

Once you have identified which equipment and areas to inspect at your facility, set schedules for routine inspections. Include examination for leaks, corrosion, support or foundation failure, or other forms of deterioration or leaks in your inspection. Look for spots or puddles of chemicals and document any detection of smoke, fumes, or other signs of leaks. Periodic testing of plant equipment for structural soundness is a key element of preventive maintenance. This can be done by making sure storage tanks are solid and strong enough to hold materials. Another important consideration is when and how often preventive maintenance inspections should be conducted to ensure that this practice is effective. Smaller facilities with little equipment and few systems may still find it necessary to conduct frequent inspections if the equipment is older and more susceptible to leaks or other discharges. Preventive maintenance inspections may be conducted as part of your regular visual inspections.

Equipment Repair or Replacement

Promptly repair or replace defective equipment found during inspections and testings. Keeping spare parts for equipment that needs frequent repair is another simple practice that can help avoid problems and equipment down-time.

Records on Preventive Maintenance

Include a suitable records system for scheduling tests and documenting inspections in the preventive maintenance program. Record test results and follow up with corrective action. Make sure records are complete and detailed. These records should be kept with other visual inspection records.

EPCRA, Section 313 Facility Preventive Maintenance Inspection Requirements

EPA's General Permit contains additional preventive maintenance inspection requirements for facilities subject to reporting under EPCRA, Section 313 for water priority chemicals [Part IV.D.7.b.(7)]. For these facilities, all areas of the facility must be inspected for the following at appropriate intervals as specified in the plan:

- Leaks or conditions that would lead to discharges of Section 313 water priority chemicals
- Conditions that could lead to direct contact of storm water with raw materials, intermediate materials, waste materials or products
- Examine piping, pumps, storage tanks and bins, pressure vessels, process and material handling equipment, and material bulk storage areas for leaks, wind blowing, corrosion, support or foundation failure, or other deterioration or noncontainment.

These inspections must occur at intervals based on facility design and operational experience, and the timing must be specified in the plan.

When a leak or other threatening condition is found, corrective action must be taken immediately or the facility unit or process must be shut down until the problem is repaired.

Visual Inspections

EPA GENERAL PERMIT REQUIREMENTS

Visual Inspections

Part IV.D.3.d.

- Identify qualified plant personnel who will inspect plant equipment and areas at appropriate intervals in the plan
- Track results of inspections to ensure that appropriate actions are taken
- Maintain records of all inspections.

Preventing pollution of storm water runoff from your facility requires good housekeeping in areas where materials are handled, stored, or transferred and preventive maintenance of process equipment and systems. Such practices are described in detail above and should be outlined in your Storm Water Pollution Prevention Plan. Regular visual inspections are your means to ensure that all of the elements of the plan are in place and working properly.

Routine visual inspections are not meant to be a comprehensive evaluation of the entire storm water pollution prevention program—that is the function of the Annual Site Inspection and Site Evaluation described in Section 2.5.1 below. Rather, they are meant to be a routine look-over of the facility to identify conditions which may give rise to contamination of storm water runoff with pollutants from your facility.

Every facility is different, so it is up to the facility owner/operator to determine what areas of your facility could potentially contribute pollutants to storm water runoff, and to devise and implement a visual inspection program based on this information. The visual inspection is simply a way to confirm that the measures chosen are in place and working and should periodically take place during storm events. The frequency of visual inspection should be determined by the types and amounts of materials handled at the facility, existing BMPs at the facility, and any other factors that may be relevant, such as the age of the facility (in general, older facilities should be inspected at more frequent intervals than new facilities). The following lists identify some types of equipment and plant areas to include in your Visual Inspections and preventive maintenance plan:

Areas to Inspect

- Areas around all of equipment listed in Preventive Maintenance box
- Areas where spills and leaks have occurred in the past
- Material storage areas (tank farms, drum storage)
- Outdoor material processing areas
- Material handling areas (e.g., loading, unloading, transfer)
- Waste generation, storage, treatment and disposal areas.

Implementation of a Visual Inspection Plan

The best plan is a simple one, and this includes the visual inspection plan - there is no reason for it to be highly technical, complicated or labor-intensive. If your facility already has a routine surveillance program in place, consider expanding it to include the visual inspection element of your Storm Water Pollution Prevention Plan. For example, if your facility has a security surveillance program, you might consider training facility security personnel to perform the visual inspection program. If your facility has no routine surveillance or inspection program already in place, then a plan must be developed and people must be assigned the responsibility for carrying the inspections out. It is important to remember that the employees carrying out the visual inspection program should be properly trained, familiar with the storm water pollution prevention program, and knowledgeable about proper recordkeeping and reporting procedures.

Records of Inspections

The most important thing for you to remember here is to document all inspections. Inspection records should note when inspections were done, who conducted the inspection, what areas were inspected, what problems were found, and steps taken to correct any problems, including who has been notified. Many industrial facilities will already have some sort of incident reporting procedure in place — existing incident reporting and security surveillance procedures could easily be incorporated into the Storm Water Pollution Prevention Plan. These records should be kept with the plan. EPA's General Permit requires that records be kept until at least one year after coverage under the permit expires.

| Visual Inspection Checklist |
|---|
| Do you see: |
| <input type="checkbox"/> Corroded drums or drums without plugs or covers |
| <input type="checkbox"/> Corroded or damaged tanks, tank supports, and tank drain valves |
| <input type="checkbox"/> Torn bags or bags exposed to rain water |
| <input type="checkbox"/> Corroded or leaking pipes |
| <input type="checkbox"/> Leaking or improperly closed valves and valve fittings |
| <input type="checkbox"/> Leaking pumps and/or hose connections |
| <input type="checkbox"/> Broken or cracked dikes, walls or other physical barriers designed to prevent storm water from reaching stored materials |
| <input type="checkbox"/> Windblown dry chemicals |
| <input type="checkbox"/> Improperly maintained or overloaded dry chemical conveying systems |

Spill Prevention and Response

EPA GENERAL PERMIT REQUIREMENTS

Spill Prevention and Response

Part IV.D.3.c.

- Identify areas where spills can occur onsite and their drainage points
- Specify material handling procedures, storage requirements, and use of equipment such as diversion valves, where appropriate
- Identify procedures used for cleaning up spills and inform personnel about these procedures
- Provide the appropriate spill clean-up equipment to personnel.

Spills and leaks together are one of the largest industrial sources of storm water pollutants, and in most cases are avoidable. Establishing standard operating procedures such as safety and spill prevention procedures along with proper employee training can reduce these accidental releases. Avoiding spills and leaks is preferable to cleaning them up after they occur, not only from an environmental standpoint, but also because spills cause increased operating costs and lower productivity.

Development of spill prevention and response procedures is a very important element of an effective Storm Water Pollution Prevention Plan. A spill prevention and response plan may have already been developed in response to other environmental regulatory requirements. If your facility already has a spill prevention and response plan, it should be evaluated and revised if necessary to address the objectives of the Storm Water Pollution Prevention Plan.

The next section outlines the steps you should take to identify and characterize potential spills, to eliminate or reduce spill potential, and how to respond when spills occur.

Identify Potential Spill Areas

As part of the Assessment Phase of developing the Storm Water Pollution Prevention Plan, you should have created a list or inventory of materials handled, used, and disposed of. A site map indicating the drainage area of each storm water outfall was also created. Now overlay the drainage area map with the locations of areas and activities with high material spill potential to determine where spills will most likely occur. Spill potential also depends on how materials are handled, the types and volumes of materials handled, and how materials are stored on your site. You must describe these factors in your plan.

The activities and areas where spills are likely to occur on your site are listed and described below:

- Loading and unloading areas
- Storage areas
- Process activities

- Dust or particulate generating processes
- Waste disposal activities.

Loading and unloading areas have a high spill potential because the nature of the activity involves transfer of materials from one container to another. The spill potential is affected by the integrity of the container, the form of the chemical being transferred, the design of the transfer area (bermed vs. direct connection to the storm water collection system), the proximity of this area to the storage area, and procedures for loading and unloading. Evaluate the spill potential from all loading and unloading equipment, such as barges, railroad cars, tank trucks, and front end loaders, as well as storage and vehicle wash areas.

Storage areas, both indoor and outdoor, are potential spill areas. Outdoor storage areas are exposed to storm water runoff and may provide direct contact between potential pollutants and storm water. Indoor storage areas may contaminate storm water if the drains in the storage area are connected to the storm sewer or if improper clean up procedures in the event of a spill are used. This evaluation should consider the type, age, and condition of storage containers and structures (including tanks, drums, bags, bottles). An evaluation of the spill potential of storage areas should also focus on how employees handle materials.

All process areas are potential sources of storm water contamination if the floor drains in these areas are connected to storm sewers (see Section 2.2.4). If these drains cannot be sealed, the process area should be evaluated for the adequacy of spill control structures such as secondary containment, if necessary. One should also consider normal housekeeping procedures. Some process areas are hosed down periodically and the resulting wash water contains pollutants. Outdoor process activities may contaminate storm water if spills are diverted to the storm sewer.

Also, evaluate spill potential from the following stationary facilities:

- Manufacturing areas
- Warehouses
- Chemical processing and or blending areas
- Temporary and permanent storage sites
- Power generating facilities
- Food processing areas
- Tank farms
- Service stations
- Parking lots
- Access roads.

Also evaluate the possibility of storm water contamination from underground sources, such as tanks and pipes. Leaking underground storage tanks are often a source of storm water contamination.

In addition to identifying these and other potential spill areas, projecting possible spill volume and type of material is critical to developing the correct response procedures for a particular area.

Specify Material Handling Procedures and Storage Requirements

Through the process of developing various spill scenarios, ideas for eliminating or minimizing the spill or its impact will emerge. These solutions should be prioritized and adopted according to conditions of effectiveness, cost, feasibility, and ease of implementation. Following is a list of some suggested activities or alterations that may be made to reduce the potential that spills will occur or impact storm water quality:

- Develop ways to recycle, reclaim and/or reuse process materials to reduce the volume brought into the facility
- Install leak detection devices, overflow controls, and diversion berms
- Disconnect drains from processing areas that lead to the storm sewer (however, be sure that any such action would not create a health hazard within your facility)
- Adopt effective housekeeping practices
- Adopt a materials flow/plant layout plan (i.e., do not store bags that are easily punctured near high-traffic areas where they may be hit by moving equipment or personnel)
- Perform regular visual inspections to identify signs of wear on tanks, drums, containers, storage shelves, and berms and to identify sloppy housekeeping or other clues that could lead to potential spills
- Perform preventive maintenance on storage tanks, valves, pumps, pipes, and other equipment
- Use filling procedures for tanks and other equipment that minimize spills
- Use material transfer procedures that reduce the chance of leaks or spills
- Substitute less or non-toxic materials for toxic materials
- Ensure appropriate security.

Identify Spill Response Procedures and Equipment

In the event that spill prevention measures fail, a swiftly executed response may prevent contamination of storm water. Spill response plans are required by numerous programs for various reasons. However, this may be the first time that a spill response plan specifically addresses protection of storm water quality.

Past experience has shown that the single most important obstacle to an effective spill response plan is its implementation. Develop the plan with its ease of implementation in mind. The spill response procedures should be clear, concise, step-by-step instructions for responding to the spill events at a particular facility. Organize the plan to facilitate rapid identification of the appropriate set of procedures. For example, you may find that the plan works best for your facility when organized by spill location. Another possible method of organization is by spilled material. The key component to implementation is the ability of employees to use the plan quickly and effectively. The specific approach you take will depend on the specific conditions at your facility such as size, number of employees and the spill potential of the site.

The spill response plan is developed based on the spill potential scenarios identified. It reflects a consideration of the potential magnitude and frequency of spills, of the types of materials spilled,

and of the variety of potential spill locations. Specific procedures may be needed to correspond to particular chemicals onsite. At all times during the operation of a facility, personnel with appropriate training and authority should be available to respond to spills.

The spill response plan should describe:

- Identification of spill response "team" responsible for implementing the spill response plan.
- Safety measures.
- Procedures to notify appropriate authorities providing assistance [police, fire, hospital, Publicly Owned Treatment Works (POTW), etc.].
- Spill containment, diversion, isolation, cleanup.
- Spill response equipment including:
 - Safety equipment such as respirators, eye guards, protective clothing, fire extinguisher, and two-way radios.
 - Cleanup equipment such as booms, barriers, sweeps, adsorbents, containers, etc.

Following any spills, evaluate how the prevention plan was successful or unsuccessful in responding and how it can be improved.

EPCRA, Section 313, Facility Spill Prevention and Response Requirements

EPA's General Permit sets forth more specific requirements for facilities subject to reporting under EPCRA, Section 313 for water priority chemicals [Part IV.D.7.b.(7)]. When a leak or spill of a Section 313 water priority chemical has occurred, the contaminated soil, material, or debris must be removed promptly and disposed of in accordance with Federal, State, and local requirements and as described in the Storm Water Pollution Prevention Plan.

These facilities are also required to designate a person responsible for spill prevention, response, and reporting procedures (see Section 2.1.1, Pollution Prevention Team).

Sediment and Erosion Control

EPA GENERAL PERMIT REQUIREMENTS

Sediment and Erosion Control

Part IV.D.3.h.

Identify areas which, due to topography, activities, or other factors, have a high potential for significant soil erosion, and identify structural, vegetative, and/or stabilization measures to be used to limit erosion.

There may be certain areas on your site which, due to construction activities, steep slopes, sandy soils, or other reasons, are prone to soil erosion. Construction activities typically remove grass and other protective ground covers resulting in the exposure of underlying soil to wind and rain. Similarly, steep slopes or sandy soils may not be able to hold plant life so that soils are exposed. Because the soil surface is unprotected, dirt and sand particles are easily picked up by wind and/or washed away by rain. This process is called erosion. Erosion can be controlled or prevented with the use of certain BMPs. A number of these measures are described in Chapter 4.

Management of Runoff

EPA GENERAL PERMIT REQUIREMENTS

Management of Runoff

Part IV.D.3.i.

The plan shall contain a narrative consideration of the appropriateness of traditional storm water management practices (practices other than those which control the source of pollutants) used to divert, infiltrate, reuse, or otherwise manage storm water runoff in a manner that reduces pollutants in storm water discharges from the site. The plan shall provide that measures determined to be reasonable and appropriate shall be implemented and maintained. The potential of various sources at the facility to contribute pollutants to storm water discharges associated with industrial activity (see Part IV.D.2. (description of potential pollutant sources) of this permit) shall be considered when determining reasonable and appropriate measures. Appropriate measures may include: vegetative swales and practices, reuse of collected storm water (such as for a process or as an irrigation source), inlet controls (such as oil/water separators), snow management activities, infiltration devices, and wet detention/retention devices.

Many BMPs discussed in this chapter are measures to reduce pollutants at the source before they have an opportunity to contaminate storm water runoff. Traditional storm water management practices also can be used to direct storm water away from areas of exposed materials or potential pollutants. Further, traditional storm water management practices can be used to direct storm water that contains pollutants to natural or other types of treatment locations. For example, using an oil/water separator on storm water that has oil and grease in it will take out some of the oil and grease before the storm water leaves the site. Permits will generally not require specific storm water management practices since these practices must be selected on a case-by-case basis depending on the activities at your site and the amount of space you have available.

Chapter 4 provides descriptions of several traditional storm water management practices. Additional sources of information are listed in Appendix A.

2.3.2 Advanced Best Management Practices

In addition to those BMPs that should be routinely incorporated into your storm water prevention pollution plan, you may need to implement some "advanced" BMPs that are specifically directed to address particular pollutant sources or activities on your site. As discussed in Chapters 3 and 4, these BMPs must be tailored to address specific problems.

In determining which BMPs represent the Best Available Technology Economically Achievable (BAT), the following factors are considered: (1) the age of equipment and facilities involved; (2) the process employed; (3) the engineering aspects of the application of various types of control techniques; (4) process changes; (5) the cost of achieving effluent reduction; and (6) non-water quality environmental impact (including energy requirements).

BMP Cost and Effectiveness

The costs of implementing the BMPs described in this manual vary depending upon many factors and site-specific conditions. In general, the required baseline BMPs are relatively low in cost when compared with more traditional storm water treatment or highly engineered controls. Costs also vary depending upon the size of the facility, the number of employees, the types of chemicals or raw materials stored or used, and the nature of plant operations. However, because many of the baseline practices are widely accepted and considered "common sense" or standard good operating practices, many facilities have them in place.

Because BMP effectiveness is also site-specific, this manual does not attempt to provide specific guidance on this matter.

Reduce, Reuse, Recycle

As described in Chapter 1, EPA encourages industrial facilities to choose practices that prevent the contamination of storm water rather than treat it once it is polluted. Use of the Storm Water Management Hierarchy (see Table 2.1) as a tool to help select BMPs for your program will help you discover how to prevent pollution and avoid its associated costs and liabilities while meeting the environmental goals of EPA's Storm Water Program.

When selecting a BMP for your storm water management program, EPA recommends that you choose practices that eliminate or reduce the amount of pollutants generated on your site. This practice is referred to as "source reduction." When it is impossible, select options that recycle or reuse the storm water in your industrial processes, or those that reduce the need to store and expose more hazardous materials to storm water by recycling or recovering used materials. Treating storm water to remove pollutants before they leave the site is the next best option, although this often just transfers the problem from one place or medium to another. Table 2.1, below, provides examples of BMPs that are representative of the different types of storm water management.

TABLE 2.1 CLASSIFICATION OF STORM WATER BMPs

| Storm Water Management Hierarchy | Example BMPs |
|----------------------------------|---|
| Source Reduction | <ul style="list-style-type: none"> • Preventive maintenance • Spill prevention • Chemical substitution • Housekeeping • Training • Materials management practices |
| Containment/Diversion | <ul style="list-style-type: none"> • Segregating the activity of concern • Covering the activity • Berming the activity • Diverting flow to grassed area • Dust control |
| Recycling | <ul style="list-style-type: none"> • Recycling |
| Treatment | <ul style="list-style-type: none"> • Oil/water separator • Vegetated swale • Storm water detention pond |

2.3.3 Completing the BMP Identification Phase

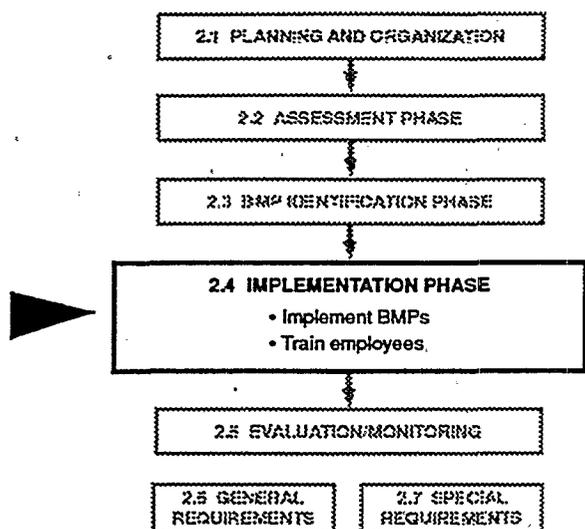
When you started designing your pollution prevention plan, you assembled certain crucial pieces of information:

- A list of actual and potential storm water discharge problems
- The location of each outfall on a site map showing the drainage route from your property
- A list of the management plans and practices that are already in place at your facility
- Information contained in this manual on "baseline" BMPs and "advanced" BMPs for resolving storm water problems.

At the completion of the BMP identification phase, you should have accomplished the following:

- Reviewed your current management plans and practices to assess their effectiveness in addressing storm water discharges on your site.
- Scheduled the implementation of "baseline" BMPs and whatever "advanced" BMPs were necessary to effectively eliminate storm water pollution problems at your site.
- Determined what to do about any identified, unpermitted connections of non-storm water discharges to separate storm sewers. Your options were to:
 - Discontinue any connections of non-storm water discharges to a separate storm sewer system
 - Obtain an NPDES permit for the non-storm water discharge.

- Identified options for addressing any unresolved storm water discharge problems.
- Gained management approval and acceptance of the plan.



2.4 IMPLEMENTATION PHASE

At this point, you have designed your Storm Water Pollution Prevention Plan and the plan has been approved by facility management. This next section of the manual will guide you through the next major phase in the planning process—implementation. Specifically, you will:

- Implement the selected storm water BMPs
- Train all employees to carry out the goals of the plan.

2.4.1 Implement Appropriate Controls

| EPA GENERAL PERMIT REQUIREMENTS |
|--|
| Implementation Part IV.D. |
| Facilities must implement the provisions of the storm water pollution prevention plan as a condition of EPA's general permit. The plan shall include a schedule for implementing identified storm water management controls. |

Implementing your plan will involve several steps:

- Develop a schedule for implementation. For example, your schedule might include a deadline for putting improved housekeeping measures into practice. Should implementation involve certain types of modifications to your site (e.g., any construction), you will need to account for the time required to secure any necessary local or State permits.
- Assign specific individuals with responsibility for implementing aspects of the plan and/or monitoring implementation.
- Ensure that management approves of your implementation schedule and strategy and schedule regular times for reporting progress to management.

Worksheet #8 (located at the end of Chapter 2) will help you list the schedule for implementation of your facility's plan.

2.4.2 Employee Training

| EPA GENERAL PERMIT REQUIREMENTS |
|---|
| <p style="text-align: center;">Employee Training Part IV.D.3.e.</p> <p>Employee training programs must inform personnel at all levels of responsibility of the components and goals of the Storm Water Pollution Prevention Plan. Training should address each component of your pollution prevention plan, including how and why tasks are to be implemented. Topics will include:</p> <ul style="list-style-type: none">• Spill prevention and response• Good housekeeping• Material management practices. <p>The pollution prevention plan must specify how often training is conducted.</p> |

Employee training is essential to effective implementation of the Storm Water Pollution Prevention Plan. The purpose of a training program is to teach personnel at all levels of responsibility the components and goals of the Storm Water Pollution Prevention Plan. When properly trained, personnel are more capable of preventing spills, responding safely and effectively to an accident when one occurs, and recognizing situations that could lead to storm water contamination.

The following sections include ideas about how to create an effective storm water pollution prevention training program for your facility.

Worksheet #9 (located at the end of Chapter 2) is designed to help you organize your employee training program.

Spill Prevention and Response

Spill prevention and response procedures are described in detail in Section 2.3.1. Discuss these procedures or plans in the training program in order to ensure all plant employees, not just those on the spill response teams, are aware of what to do if a spill occurs. Specifically, all employees involved in the industrial activities of your facility should be trained about the following measures:

- Identifying potential spill areas and drainage routes, including information on past spills and causes
- Reporting spills to appropriate individuals, without penalty (e.g., employees should be provided "amnesty" when they report such instances)
- Specifying material handling procedures and storage requirements
- Implementing spill response procedures.

Onsite contractors and temporary personnel should also be informed of the plant operations and design features in order to help prevent accidental discharges or spills from occurring.

Good Housekeeping

Also, teach facility personnel how to maintain a clean and orderly work environment. Section 2.3.1 above outlines the steps for practicing good housekeeping. Emphasize these points in the good housekeeping portion of your training program:

- Require regular vacuuming and/or sweeping
- Promptly clean up spilled materials to prevent polluted runoff
- Identify places where brooms, vacuums, sorbents, foams, neutralizing agents, and other good housekeeping and spill response equipment are located
- Display signs reminding employees of the importance and procedures of good housekeeping
- Discuss updated procedures and report on the progress of practicing good housekeeping at every meeting
- Provide instruction on securing drums and containers and frequently checking for leaks and spills
- Outline a regular schedule for housekeeping activities to allow you to determine that the job is being done.

Materials Management Practices

- Neatly organize materials for storage
- Identify all toxic and hazardous substances stored, handled, and produced onsite
- Discuss handling procedures for these materials.

Tools For a Successful Training Program

Here are some suggestions of training tools that you can include in your facility's training program:

- Employee handbooks
- Films and slide presentations
- Drills
- Routine employee meetings
- Bulletin boards
- Suggestion boxes
- Newsletters
- Environmental excellence awards or other employee incentive programs.

Providing employees with incentives, such as awards for practicing pollution prevention, is a good way to motivate personnel in working to achieve the goals of the Storm Water Pollution Prevention Plan.

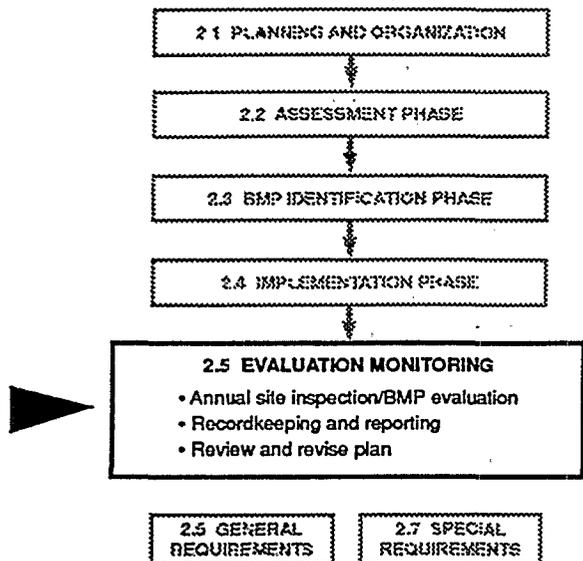
How Often to Conduct Training

You should examine your plan to determine how often you should train the employees at your facility. Frequency should take into account the complexity of your management practices and the nature of your staff, including staff turnover and changes in job assignments. Facilities are required to specify a schedule for periodic training activities in their plan. In any case, you should regularly evaluate the effectiveness of your training efforts. In many cases, this will simply involve speaking with your employees to verify that information has been communicated effectively.

EPCRA, Section 313 Facility Requirements

EPA's General Permit contains additional training requirements for employees and contractor personnel that work in areas where EPCRA, Section 313 water priority chemicals are used or stored [Part IV.D.7.b.(9)]. These individuals must be trained in the following areas at least once per year:

- Preventive measures, including spill prevention and response and preventive maintenance
- Pollution control laws and regulations
- The facility's Storm Water Pollution Prevention Plan
- Features and operations of the facility which are designed to minimize discharges of Section 313 water priority chemicals, particularly spill prevention procedures.



2.5 EVALUATION PHASE

Now that your Storm Water Pollution Prevention Plan has been put to action, you must keep it up-to-date by regularly evaluating the information you collected in the Assessment Phase and the controls you selected in the BMP Identification Phase. Specifically, you will:

- Conduct site evaluations
- Keep records of all inspections and reports
- Revise the plan as needed.

2.5.1 Annual Site Compliance Evaluation

| EPA GENERAL PERMIT REQUIREMENTS |
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| Comprehensive Site Compliance Evaluation Part IV.D.4. |
| <p>Qualified personnel must conduct site compliance evaluations at appropriate intervals specified in the plan at least once a year (at least once in three years for inactive mining sites). As part of your compliance evaluations, you are required to:</p> <ul style="list-style-type: none"> • Inspect storm water drainage areas for evidence of pollutants entering the drainage system • Evaluate the effectiveness of measures to reduce pollutant loadings and whether additional measures are needed • Observe structural measures, sediment controls, and other storm water BMPs to ensure proper operation • Inspect any equipment needed to implement the plan, such as spill response equipment • Revise the plan as needed within two weeks of inspection (potential pollutant source description and description of measures and controls) • Implement any necessary changes in a timely manner, but at least within 12 weeks of the inspection • Prepare a report summarizing inspection results and follow up actions, the date of inspection and personnel who conducted the inspection; identify any incidents of noncompliance <u>or</u> certify that the facility is in compliance with the plan. • All incidents of noncompliance must be documented in the inspection report. Where there are no incidents of noncompliance, the inspection report must contain a certification that the facility is in compliance with the plan. • Sign the report in accordance with Section 2.6.2 and keep it with the plan. |

Annual site compliance evaluations are comprehensive inspections performed by individuals specifically designated in the Storm Water Pollution Prevention Plan as having responsibility for conducting such inspections. These employees should be familiar with all facility industrial operations and Storm Water Pollution Prevention Plan goals and requirements. Furthermore, inspectors should be able to make necessary management decisions or have direct access to management.

This annual evaluation provides a basis for evaluating the overall effectiveness of your Storm Water Pollution Prevention Plan. In particular, the annual site compliance evaluation will allow you to verify that the description of potential pollutant sources contained in the plan is accurate, that the plan drainage map is accurate or has been updated to reflect current conditions, and that controls identified in the plan to reduce pollutants in storm water discharges are accurately identified, in place and working. The annual site compliance evaluation will also identify where new controls are needed so that you may implement them and incorporate them into the plan.

The scope of the annual site compliance evaluation will depend on various factors, including the scope of the Storm Water Pollution Prevention Plan and the size and nature of the activities occurring at the facility. The process for conducting the evaluation should follow these steps:

- Review the Storm Water Pollution Prevention Plan and draw up a list of those items which are part of material handling, storage, and transfer areas covered by the plan
- List all equipment and containment in these areas covered in the plan
- Review facility operations for the past year to determine if any more areas should be included in the original plan, or if any existing areas were modified so as to require plan modification; change plan as appropriate
- Conduct inspection to determine (1) if all storm water pollution prevention measures are accurately identified in the plan, and (2) are in place and working properly
- Document findings
- Modify Storm Water Pollution Prevention Plan as appropriate.

As each facility and Storm Water Pollution Prevention Plan is unique, so the exact inspection format will vary from facility to facility. All documentation regarding conditions necessitating modification to the Storm Water Pollution Prevention Plan should be kept on file as part of the plan until one year after coverage under the permit expires.

2.5.2 Recordkeeping and Internal Reporting

| EPA GENERAL PERMIT REQUIREMENTS |
|--|
| Keeping Records Part IV.D.3.f. |
| Incidents such as spills or other discharges, along with other information describing the quality and quantity of storm water discharges must be included in the records. Inspections and maintenance activities shall be documented and recorded in the plan. Records must be maintained for one year after the permit expires. |

Keeping records of and reporting events that occur onsite is an effective way of tracking the progress of pollution prevention efforts and waste minimization. Analyzing records of past spills, for example, can provide useful information for developing improved BMPs to prevent future spills of the same kind. Recordkeeping and internal reporting represent good operating practices because they can increase the efficiency of the facility and effectiveness of BMPs.

Recordkeeping and Reporting Procedures for Spills, Leaks, and Other Discharges

A recordkeeping system set up for documenting spills, leaks, and other discharges, including discharges of hazardous substances in reportable quantities (for a discussion of reportable quantities, see Section 2.2.3 and Appendix H), could help your facility minimize incident recurrence, correctly respond with appropriate cleanup activities, and comply with legal requirements. The system for recordkeeping and reporting could also include any other information that would enhance the effectiveness of the Storm Water Pollution Prevention Plan. You should make a point of keeping track of reported incidents and following up on results of inspections and reported spills, leaks, or other discharges.

Records should include the following, as appropriate:

- The date and time of the incident, weather conditions, duration, cause, environmental problems, response procedures, parties notified, recommended revisions of the BMP program, operating procedures, and/or equipment needed to prevent recurrence.
- Formal written reports. These are helpful in reviewing and evaluating the discharges and making revisions to improve the BMP program. Document all reports you call in to the National Response Center in the event of a reportable quantity discharge. For more information on reporting spills or other discharges, refer to Section 2.2.3 and 40 CFR 117.3 and 40 CFR 302.4.
- A list of the procedures for notifying the appropriate plant personnel and the names and telephone numbers of responsible employees. This enables more rapid reporting of and response to spills and other incidents.

Recordkeeping and Reporting Procedures for Inspections and Maintenance Activities

Maintaining records for all inspections is an important element of any Storm Water Pollution Prevention Plan. Documenting all inspections, whether routine or detailed, is a good preventive maintenance technique, because analysis of inspection records allows for early detection of any potential problems. Recordkeeping also helps to devise improvements in the BMP program after inspection records have been analyzed. Recordkeeping and reporting for maintenance activities should also be a part of the plan as another preventive maintenance measure. Keeping a log of all maintenance activities, such as the cleaning of oil and grit separators or catch basins, will enable the facility to evaluate the effectiveness of the BMP program, equipment, and operation.

There are various simple techniques used to accurately document and report inspection results including the following:

- Field notebooks
- Timed and dated photographs

- Video tapes
- Drawings and maps.

Keeping Records Updated

It is important to keep all records updated on:

- The correct name and address of facility
- The correct name and location of receiving waters
- The number and location of discharge points
- Principal products and production rates (where appropriate).

Records Retention

Records of spills, leaks, or other discharges, inspections, and maintenance activities must be retained for at least one year after coverage under the permit expires.

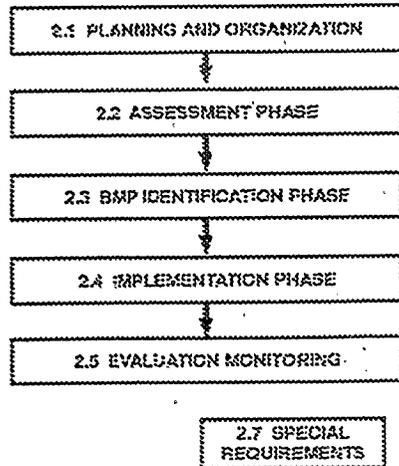
2.5.3 Plan Revisions

| |
|--|
| <p style="text-align: center;">EPA GENERAL PERMIT REQUIREMENTS</p> <p style="text-align: center;">Keeping Plans Current Part IV.C</p> <p>You must amend your plan whenever there is a change in design, construction, operation, or maintenance, which may impact the potential for pollutants to be discharged or if the Storm Water Pollution Prevention Plan proves to be ineffective in controlling the discharge of pollutants. Facilities are not required to submit a notice to the Director each time the pollution prevention plan is modified unless the Director specifically requests changes to be made to the plan.</p> |
|--|

For your Storm Water Pollution Prevention Plan to be effective, you should ensure that your plan complies with any permit conditions that apply to your facility and that you have accurately represented facility features and operations. Should either of these conditions not be met by the plan, you must make the necessary changes. Either the managers of facilities or the permitting authority may recommend changes to the plan (see Section 2.6.4 for requirements).

Storm Water Pollution Prevention Plans are developed based on site-specific features. When there are changes in design, construction, operation, or maintenance, and that change will have a significant effect on the potential for discharging pollutants in storm water at a facility, your Storm Water Pollution Prevention Plan should be modified to reflect the changes and new conditions. For example, if your facility begins to use a new chemical in its production operations, proper handling procedures for this chemical should be incorporated into the facility plan.

You may also decide to change the plan because it has proven to be ineffective in controlling storm water contamination based on the results of routine visual inspections (see Section 2.3.1) or more comprehensive site evaluations (see Section 2.5.1).



2.6 GENERAL REQUIREMENTS

This Section provides guidance on some of the administrative requirements related to organizing and developing your Storm Water Pollution Prevention Plan. This information should be reviewed prior to beginning to develop your facility's Storm Water Pollution Prevention Plan. These requirements include:

- Deadlines for plan development and implementation
- Who must sign the plan
- Where to keep the plan
- How to make changes to the plan that are required by the Director.

2.6 GENERAL REQUIREMENTS

- Deadlines
- Signature requirements
- Plan location and public access
- Required plan modification

2.6.1 Schedule for Plan Development and Implementation

| EPA GENERAL PERMIT REQUIREMENTS | | |
|--|---|---|
| Schedule for Plan Development and Implementation Part IV.A. | | |
| Type of Facility | Deadline for Plan Completion | Deadline for Plan Compliance |
| Facilities with industrial activities existing on or before October 1, 1992 | April 1, 1993 | October 1, 1993 |
| Facilities commencing industrial activities after October 1, 1992, but on or before December 31, 1992 | 60 days after commencement of discharge | 60 days after commencement of discharge |
| Facilities commencing industrial activities on or after January 1, 1993 | 48 hours prior to commencement of discharge (upon submittal of NOI) | 48 hours prior to commencement of discharge (upon submittal of NOI) |
| Oil and gas exploration, production, processing or treatment operations discharging a reportable quantity release in storm water after October 1, 1992 | 60 days after release | 60 days after release |
| Industrial facilities that are owned or operated by a municipality that are rejected or denied from the group application process | 365 days after date of rejection or denial | 545 days after date of rejection or denial |
| Note: The Director may grant a written extension for plan preparation and compliance for new dischargers (after October 1, 1992) upon showing of good cause. | | |

The deadlines to complete and comply with or implement your facility's Storm Water Pollution Prevention Plan may depend on the type of permit under which your facility is covered. Be sure to read your permit carefully so that you know what the deadlines are. Many NPDES-delegated States may issue general permits for storm water that contain deadlines similar to the deadlines in EPA's General Permits.

2.6.2 Required Signatures

| EPA GENERAL PERMIT REQUIREMENTS |
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| <p style="text-align: center;">Signature Requirements</p> <p style="text-align: center;">Part VII.G.1.</p> <p>Where your facility is subject to storm water permit requirements, all reports, certifications, or information either submitted to the permitting authority or to the operator of a large or medium municipal separate storm sewer system, or required to be maintained by the permittee onsite should be signed as follows:</p> <ul style="list-style-type: none">• For a corporation, the plan must be signed by a "responsible corporate officer." A responsible corporate officer may be <u>any one of the following</u>:<ul style="list-style-type: none">- A president, secretary, treasurer, or vice-president of the corporation in charge of a principal business function, or any other person who performs similar policy or decision-making functions for the corporation- The manager of one or more manufacturing, production, or operating facilities employing more than 250 persons or having gross annual sales or expenditures exceeding \$25,000,000 (in second quarter 1980 dollars) if authority to sign documents has been assigned or delegated to the manager in accordance with corporate procedure.• For a partnership or sole proprietorship, the plan must be signed by a general partner or the proprietor, respectively.• For a municipality, State, Federal, or other public agency, the plan must be signed by either:<ul style="list-style-type: none">- The principal executive officer or ranking official, which includes the chief executive officer of the agency, or- The senior officer having responsibility for the overall operations of a principal geographic unit of the agency. |
| <p style="text-align: center;">Designating Signatory Authority</p> <p style="text-align: center;">Part VII.G.2.</p> <p>Any of the above persons may designate a duly authorized representative to sign for them. The representative should either have overall responsibility for the operation of the facility or environmental matters for the company. If an authorized representative is appointed, the authorization must be put in writing by the responsible signatory and submitted to the Director. Any change in an authorized individual or an authorized position must be made in writing and submitted to the permitting authority.</p> |

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| <p>EPA GENERAL PERMIT REQUIREMENTS</p> <p>Certification Part VII.G.2.d.</p> <p>Any person signing documents under this permit shall make the following certification: "I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."</p> |
|--|

To ensure that your facility's Storm Water Pollution Prevention Plan is completely developed and adequately implemented, your NPDES permit will generally require that an authorized facility representative sign and certify the plan. The authorized facility representative should be someone at or near the top of your facility's management chain, such as the president, vice president, or a production manager who has been delegated the authority to sign and certify this type of document. In signing the plan, the corporate officer is attesting that the information is true. This signature provides a basis for an enforcement action to be taken against the person signing the plan and related reports. The permittee should be aware that Section 309 of the Clean Water Act provides for significant penalties where information is false or the permittee violates, either knowingly or negligently, its permit requirements. In some cases, your general permit may require certification of the plan by a professional engineer. Specific signatory requirements will be listed in your NPDES permit.

EPCRA, Section 313 Facility Plan Certification Requirements

EPA's General Permit contains additional certification requirements for facilities subject to reporting under EPCRA, Section 313 for water priority chemicals [Part IV.D.7.b.(10)]. The plan must be reviewed and certified by a Registered Professional Engineer and recertified every three years or as soon as practicable after significant modifications are made to the facility. This certification that the plan was prepared in accordance with good engineering practices does not relieve the facility owner or operator of responsibility to prepare and implement the plan, however.

2.6.3 Plan Location and Public Access

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| <p>EPA GENERAL PERMIT REQUIREMENTS</p> <p>Where and How Long to Keep the Plan Parts IV.B. and VI.E.</p> <p>Plans are required to be maintained onsite of the facility unless the Director, or authorized representative, or the operator of a large or medium municipal separate storm sewer system, requests that the plan be submitted. Plans and all required records must be kept until at least one year after coverage under the permit expires.</p> |
|---|

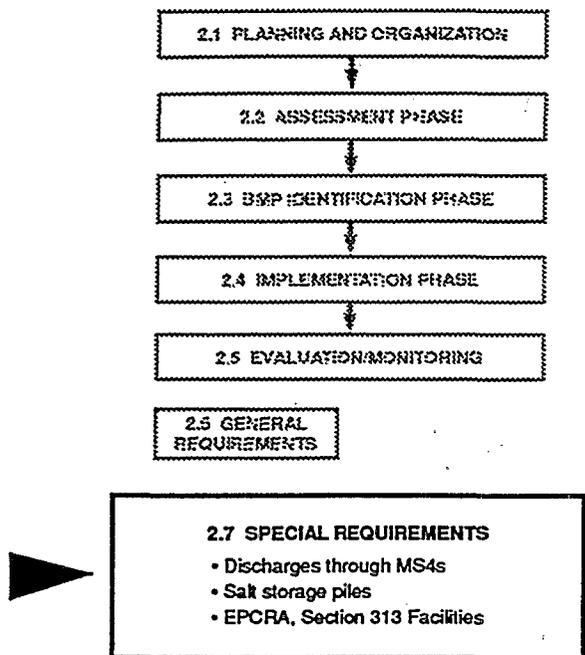
Although all plans are to be maintained onsite, some NPDES storm water permits may require that facilities submit copies of their Storm Water Pollution Prevention Plans to the Director for review. Examine your permit carefully to determine what submittal requirements apply to your facility. Even if your permit does not require you automatically to submit your plan to your permitting authority, you must provide copies of the plan to your permitting authority or to your municipal operator upon request. Plans and associated records are available to the public by request through the permitting authority.

2.6.4 Director-Required Plan Modifications

| EPA GENERAL PERMIT REQUIREMENTS |
|---|
| Required Changes |
| Part IV.B.3. |
| Any changes required by the permitting authority shall be made within 30 days, unless otherwise provided by the notification, and the facility must submit a certification signed in accordance with Section 2.6.2 to the Director that the requested changes have been made. |

Upon reviewing your plan, the permitting authority may find that it does not meet one or more of the minimum standards established by the pollution prevention plan requirements. In this case, the permitting authority will notify you of changes needed to improve the plan.

For example, where a facility has not addressed spill response procedures for a toxic chemical to the extent that the permitting authority believes is necessary, the facility will be required to revise the procedures. The permitting authority retains the authority to make this type of request at any time during the effective period of the plan. In the notification, the permitting authority will establish a deadline for the incorporation of the required changes, unless the permit specifies a deadline. Permittees may or may not have to certify that the requested changes have been implemented depending on their specific permit conditions. You should examine your permit for such details.



2.7 SPECIAL REQUIREMENTS

In addition to the minimum "baseline" BMPs discussed in previous sections, facilities may be subject to additional "special" requirements. Not all facilities will have to include these special requirements in their Storm Water Pollution Prevention Plan. Be sure to check your permit closely for these conditions. In particular, EPA's General Permit includes special requirements for:

- Facilities that discharge storm water through municipal separate storm sewer systems
- Facilities subject to EPCRA, Section 313 reporting requirements
- Facilities with salt storage piles.

2.7.1 Special Requirements for Discharges Through Municipal Separate Storm Sewer Systems

| EPA GENERAL PERMIT REQUIREMENTS |
|--|
| <p>Discharges Through Large or Medium Municipal Separate Storm Sewer Systems (MS4s)</p> <p>Part IV.D.5.</p> <p>Permittees must comply with conditions in municipal storm water management programs developed under the NPDES permit issued for that system to which the industrial facility discharges, provided that the facility was directly notified of the applicable requirements by the municipal operator. The facility must be in compliance with these conditions by the deadlines specified in the pollution prevention plan listed in Section 2.6.1.</p> |

The November 16, 1990, storm water discharge permit application regulations require large and medium municipal separate storm sewer systems (systems serving a population of 100,000 or more) to develop storm water management programs in order to control pollutants discharged through the municipal systems. These management programs will address discharges of industrial storm water through the systems to the extent that they are harmful to the water quality of receiving streams. Municipalities should be aware of the facilities with storm water discharges associated with industrial activity that discharge into their separate storm sewer system because the November 16, 1990, final rule required these facilities to notify the municipal operator. In addition, facilities covered by general permits will typically be required to submit a copy of their NOI to the municipal operator. EPA emphasizes that it is the facility's responsibility to inform the municipality of all storm water discharges associated with industrial activity to the separate storm sewer system. Facilities with such discharges that have not yet contacted the appropriate municipal authority should do so immediately.

Although facility-specific Storm Water Pollution Prevention Plans for industries are designed to prevent pollutants from entering storm water discharges, the municipal operator may find it necessary to impose specific requirements on a particular industrial facility or class of industrial

facilities in some situations. One way to ensure that facilities comply with these requirements is to include a provision in the facility's NPDES storm water discharge permit that directly requires compliance. This mechanism provides a basis for enforcement action to be directed, where necessary, against the owner or operator of the facility with a storm water discharge associated with industrial activity.

2.7.2 Special Requirements for EPCRA, Section 313 Reporting Facilities

Section 313 of EPCRA requires operators of manufacturing facilities that handle toxic chemicals in amounts exceeding threshold levels (listed at 40 CFR 372.25) to report to the government on an annual basis. Because these types of facilities handle large amounts of toxic chemicals, EPA concluded that they have an increased potential to degrade the water quality of receiving streams. To address this risk, EPA established specific control requirements in its general permit. In particular, these requirements apply to Section 313 facilities that report for "water priority chemicals" that include any of over 200 chemicals that have been identified by EPA as especially toxic to water ecosystems. For reference, Appendix I contains a list of Section 313 water priority chemicals.

Many of the requirements outlined below are specifically designed to address the water quality concerns that toxic chemicals present. Incorporation of these requirements into site-specific Storm Water Pollution Prevention Plans will prevent spills and leaks of water priority chemicals and eliminate or reduce other opportunities for exposure of toxic chemicals to storm water, thus protecting receiving streams from toxic discharges.

Specific Requirements

The following specific control requirements must be practiced in areas where Section 313 water priority chemicals are stored, handled, processed, or transferred:

- Provide containment, drainage control, and/or diversionary structures:
 - Prevent or minimize runoff by installing curbing, culverting, gutters, sewers, or other controls, and/or
 - Prevent or minimize exposure by covering storage piles.
- Prevent discharges from all areas:
 - Use manually activated valves with drainage controls in all areas, and/or
 - Equip the plant with a drainage system to return spilled material to the facility.
- Prevent discharges from liquid storage areas:
 - Store liquid materials in compatible storage containers
 - Provide secondary containment designed to hold the volume of the largest storage tank plus precipitation.

- Prevent discharges from loading/unloading areas:
 - Use drip pans and/or
 - Implement a strong spill contingency and integrity testing plan.
- Prevent discharges from handling/processing/transferring areas:
 - Use covers, guards, overhangs, door skirts
 - Conduct visual inspections or leak tests for overhead piping.
- Introduce facility security programs to prevent spills:
 - Use fencing, lighting, traffic control, and/or secure equipment and buildings.

Additional requirements are baseline BMPs that have been enhanced to address specific storm water concerns associated with the handling of toxic chemicals. These additional requirements are highlighted in previous sections on the pages indicated below:

| | |
|-------------------------------------|---------|
| Pollution Prevention Team | p. 2-5 |
| Preventive Maintenance | p. 2-27 |
| Spill Prevention Response | p. 2-34 |
| Employee Training | p. 2-42 |
| Professional Engineer Certification | p. 2-49 |

2.7.3 Special Requirements for Salt Storage Piles

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| <p>EPA GENERAL PERMIT REQUIREMENTS</p> <p>Salt Storage Piles</p> <p>Part IV.D.8.</p> <p>Where storm water from a salt storage pile is discharged to waters of the United States, the pile must be covered or enclosed to prevent exposure to precipitation, except when salt is being added to or taken from the pile. Discharges shall comply with this provision as expeditiously as practicable, but in no event later than October 1, 1995.</p> |
|--|

Facilities may use salt for de-icing purposes or part of their industrial processes. Since exposed salt piles will easily contaminate storm water runoff, an obvious BMP for these piles is to cover them with a tarp or other covering or enclose them in a shed or building. This requirement may not be applicable to all Storm Water Pollution Prevention Plans, however. Where runoff from the salt pile is not discharged to waters of the United States, then this requirement would not apply since the pollutants will not reach a waterbody. Since it may not be feasible to maintain cover over a salt pile when adding to it or taking salt from it, permits will generally incorporate some flexibility, as does EPA's General Permit.

STORM WATER POLLUTION PREVENTION PLAN WORKSHEETS

| <u>Title</u> | <u>Worksheet #</u> |
|---|--------------------|
| Pollution Prevention Team | 1 |
| Site Map | 2 |
| Material Inventory | 3 |
| Exposed Significant Materials | 3a |
| List of Significant Spills and Leaks | 4 |
| Non-Storm Water Discharge Assessment | 5 |
| Non-Storm Water Discharge Failure to Certify Form | 6 |
| Pollutant Source Identification | 7 |
| BMP Identification | 7a |
| Implementation Schedule | 8 |
| Employee Training Program/Schedule | 9 |

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**POLLUTION PREVENTION TEAM
(Section 2.1.1)**

MEMBER ROSTER

Worksheet #1

Completed by: _____

Title: _____

Date: _____

Leader: _____

Title: _____

Office Phone: _____

Responsibilities: _____

Members:

(1) _____

Title: _____

Office Phone: _____

Responsibilities: _____

(2) _____

Title: _____

Office Phone: _____

Responsibilities: _____

(3) _____

Title: _____

Office Phone: _____

Responsibilities: _____

(4) _____

Title: _____

Office Phone: _____

Responsibilities: _____

2-55

**DEVELOPING A SITE MAP
(Section 2.2.1)**

Worksheet #2

Completed by: _____

Title: _____

Date: _____

Instructions: Draw a map of your site including a footprint of all buildings, structures, paved areas, and parking lots. The information below describes additional elements required by EPA's General Permit (see example maps in Figures 2.3 and 2.4).

EPA's General Permit requires that you indicate the following features on your site map:

- All outfalls and storm water discharges
- Drainage areas of each storm water outfall
- Structural storm water pollution control measures, such as:
 - Flow diversion structures
 - Retention/detention ponds
 - Vegetative swales
 - Sediment traps
- Name of receiving waters (or if through a Municipal Separate Storm Sewer System)
- Locations of exposed significant materials (see Section 2.2.2)
- Locations of past spills and leaks (see Section 2.2.3)
- Locations of high-risk, waste-generating areas and activities common on industrial sites such as:
 - Fueling stations
 - Vehicle/equipment washing and maintenance areas
 - Area for unloading/loading materials
 - Above-ground tanks for liquid storage
 - Industrial waste management areas (landfills, waste piles, treatment plants, disposal areas)
 - Outside storage areas for raw materials, by-products, and finished products
 - Outside manufacturing areas
 - Other areas of concern (specify: _____)

2-56

MATERIAL INVENTORY
(Section 2.2.2)

Worksheet #3

Completed by: _____

Title: _____

Date: _____

Instructions: List all materials used, stored, or produced onsite. Assess and evaluate these materials for their potential to contribute pollutants to storm water runoff. Also complete Worksheet 3A if the material has been exposed during the last three years.

| Material | Purpose/Location | Quantity (units) | | | Quantity Exposed in Last 3 Years | Likelihood of contact with storm water. If yes, describe reason. | Past Significant Spill or Leak | |
|----------|------------------|------------------|----------|--------|----------------------------------|--|--------------------------------|----|
| | | Used | Produced | Stored | | | Yes | No |
| | | | | | | | | |
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2-57

DESCRIPTION OF EXPOSED SIGNIFICANT MATERIAL
(Section 2.2.2)

Worksheet #3A

Completed by: _____

Title: _____

Date: _____

Instructions: Based on your material inventory, describe the significant materials that were exposed to storm water during the past three years and/or are currently exposed. For the definition of "significant materials" see Appendix B of the manual.

| Description of Exposed Significant Material | Period of Exposure | Quantity Exposed (units) | Location (as indicated on the site map) | Method of Storage or Disposal (e.g., pile, drum, tank) | Description of Material Management Practice (e.g., pile covered, drum sealed) |
|---|--------------------|--------------------------|---|--|---|
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(2-58)

LIST OF SIGNIFICANT SPILLS AND LEAKS
(Section 2.2.3)

Worksheet #4
Completed by: _____
Title: _____
Date: _____

Directions: Record below all significant spills and significant leaks of toxic or hazardous pollutants that have occurred at the facility in the three years prior to the effective date of the permit.

Definitions: Significant spills include, but are not limited to, releases of oil or hazardous substances in excess of reportable quantities.

| 1st Year Prior | | | | | | | | | | |
|--------------------------|-------|------|--|------------------|----------|------------------|--------|------------------------------|--|---------------------------|
| Date (month/day/year) | Spill | Leak | Location (as indicated on site map) | Description | | | | Response Procedure | | Preventive Measures Taken |
| | | | | Type of Material | Quantity | Source, If Known | Reason | Amount of Material Recovered | Material No Longer Exposed to Storm Water (True/False) | |
| | | | | | | | | | | |
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| 2nd Year Prior | | | | | | | | | | |
|--------------------------|-------|------|--|------------------|----------|------------------|--------|------------------------------|--|---------------------------|
| Date (month/day/year) | Spill | Leak | Location (as indicated on site map) | Description | | | | Response Procedure | | Preventive Measures Taken |
| | | | | Type of Material | Quantity | Source, If Known | Reason | Amount of Material Recovered | Material No Longer Exposed to Storm Water (True/False) | |
| | | | | | | | | | | |
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| 3rd Year Prior | | | | | | | | | | |
|--------------------------|-------|------|--|------------------|----------|------------------|--------|------------------------------|--|---------------------------|
| Date (month/day/year) | Spill | Leak | Location (as indicated on site map) | Description | | | | Response Procedure | | Preventive Measures Taken |
| | | | | Type of Material | Quantity | Source, If Known | Reason | Amount of Material Recovered | Material No Longer Exposed to Storm Water (True/False) | |
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2-5-91

**NON-STORM WATER DISCHARGE
ASSESSMENT AND CERTIFICATION
(Section 2.2.4)**

Worksheet #5

Completed by: _____

Title: _____

Date: _____

| Date of Test or Evaluation | Outfall Directly Observed During the Test (Identify as indicated on the site map) | Method Used to Test or Evaluate Discharge | Describe Results from Test for the Presence of Non-Storm Water Discharge | Identify Potential Significant Sources | Name of Person Who Conducted the Test or Evaluation |
|----------------------------|---|---|--|--|---|
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CERTIFICATION

I, _____ (responsible corporate official), certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

A. Name & Official Title (type or print)

B. Area Code and Telephone No.

C. Signature

D. Date Signed

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**NON-STORM WATER DISCHARGE ASSESSMENT AND
FAILURE TO CERTIFY NOTIFICATION
(Section 2.2.4)**

Worksheet #6

Completed by: _____

Title: _____

Date: _____

Directions: If you cannot feasibly test or evaluate an outfall due to one of the following reasons, fill in the table below with the appropriate information and sign this form to certify the accuracy of the included information.

List all outfalls not tested or evaluated, describe any potential sources of non-storm water pollution from listed outfalls, and state the reason(s) why certification is not possible. Use the key from your site map to identify each outfall.

Important Notice: A copy of this notification must be signed and submitted to the Director within 180 days of the effective date of this permit.

| Identify Outfall Not Tested/Evaluated | Description of Why Certification Is Infeasible | Description of Potential Sources of Non-Storm Water Pollution |
|---------------------------------------|--|---|
| | | |
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CERTIFICATION

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations, and that such notification has been made to the Director within 180 days of _____ (date permit was issued), the effective date of this permit.

A. Name & Official Title (type or print)

B. Area Code and Telephone No.

C. Signature

D. Date Signed

(202)

POLLUTANT SOURCE IDENTIFICATION
(Section 2.2.6)

Worksheet #7

Completed by: _____

Title: _____

Date: _____

Instructions: List all identified storm water pollutant sources and describe existing management practices that address those sources. In the third column, list BMP options that can be incorporated into the plan to address remaining sources of pollutants.

| Storm Water Pollutant Sources | Existing Management Practices | Description of New BMP Options |
|-------------------------------|-------------------------------|--------------------------------|
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | | |
| 5. | | |
| 6. | | |
| 7. | | |
| 8. | | |
| 9. | | |
| 10. | | |

2.62

BMP IDENTIFICATION
(Section 2.3.1)

Worksheet #7a

Completed by: _____

Title: _____

Date: _____

Instructions: Describe the Best Management Practices that you have selected to include in your plan. For each of the baseline BMPs, describe actions that will be incorporated into facility operations. Also describe any additional BMPs (activity-specific (Chapter 3) and site-specific BMPs (Chapter 4)) that you have selected. Attach additional sheets if necessary.

| BMPs | Brief Description of Activities |
|--|---------------------------------|
| Good Housekeeping | |
| Preventive Maintenance | |
| Inspections | |
| Spill Prevention Response | |
| Sediment and Erosion Control | |
| Management of Runoff | |
| Additional BMPs (Activity-specific and Site-specific) | |

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IMPLEMENTATION
(Section 2.4.1)

Worksheet #8

Completed by: _____

Title: _____

Date: _____

Instructions: Develop a schedule for implementing each BMP. Provide a brief description of each BMP, the steps necessary to implement the BMP (i.e., any construction or design), the schedule for completing those steps (list dates) and the person(s) responsible for implementation.

| BMPs | Description of Action(s) Required for Implementation | Scheduled Completion Date(s) for Req'd. Action | Person Responsible for Action | Notes |
|--|--|--|-------------------------------|-------|
| Good Housekeeping | 1. | | | |
| | 2. | | | |
| | 3. | | | |
| Preventive Maintenance | 1. | | | |
| | 2. | | | |
| | 3. | | | |
| Inspections | 1. | | | |
| | 2. | | | |
| | 3. | | | |
| Spill Prevention and Response | 1. | | | |
| | 2. | | | |
| | 3. | | | |
| Sediment and Erosion Control | 1. | | | |
| | 2. | | | |
| | 3. | | | |
| Management of Runoff | 1. | | | |
| | 2. | | | |
| | 3. | | | |
| Additional BMPs (Actively-specific and site-specific) | 1. | | | |
| | 2. | | | |
| | 3. | | | |

2-14-16

EMPLOYEE TRAINING
(Section 2.4.2)

Worksheet #9

Completed by: _____

Title: _____

Date: _____

Instructions: Describe the employee training program for your facility below. The program should, at a minimum, address spill prevention and response, good housekeeping, and material management practices. Provide a schedule for the training program and list the employees who attend training sessions.

| Training Topics | Brief Description of Training Program/Materials (e.g., film, newsletter course) | Schedule for Training (list dates) | Attendees |
|-------------------------------|---|------------------------------------|-----------|
| Spill Prevention and Response | | | |
| Good Housekeeping | | | |
| Material Management Practices | | | |
| Other Topics | | | |
| | | | |
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CHAPTER

3

ACTIVITY-SPECIFIC SOURCE CONTROL BMPs

This chapter describes specific BMPs for common industrial activities that may contaminate storm water. Chapter 2 led you through the steps of identifying activities at your facility that can contaminate storm water. At this point, you should be ready to choose the BMPs that best fill your facility's need. You should read this chapter if any of the activities listed below take place at your facility. BMPs for each of these activities are provided in the sections listed below:

| Activity | Section |
|---|---------|
| Fueling | 3.1 |
| Maintaining Vehicles and Equipment | 3.2 |
| Painting Vehicles and Equipment | 3.3 |
| Washing Vehicles and Equipment | 3.4 |
| Loading and Unloading Materials | 3.5 |
| Liquid Storage in Above-Ground Tanks | 3.6 |
| Industrial Waste Management and Outside Manufacturing | 3.7 |
| Outside Storage of Raw Materials, By-Products, or Finished Products | 3.8 |
| Salt Storage | 3.9 |

Each section is presented in a question and answer format. By answering these questions, you will be able to quickly identify source controls or recycling BMPs that are suitable for your facility. The BMPs suggested are relatively easy to use, are inexpensive, and often are effective in removing the source of storm water contaminants. This is not a complete list of BMPs for every industrial activity; rather, it is meant to help you think about ways you can reduce storm water contamination on your site. You may want to contact one of the State or Federal pollution prevention assistance offices listed in Appendix D for suggestions or help in choosing or using these and other BMP options.

3.1 BMPs FOR FUELING STATIONS

When storm water mixes with fuel spilled or leaked onto the ground, it becomes polluted with chemicals that are harmful to humans and to fish and wildlife. The following questions will help you identify activities that can contaminate storm water and suggest BMPs to reduce or eliminate storm water contamination from fueling stations. Read this section if your facility has outdoor fueling operations or if fueling occurs in areas where leaks or spills could contaminate storm water. Also refer to the BMPs listed in Section 4.2 on Exposure Minimization.

Q. Have you installed spill and overfill prevention equipment?

Fuel overflows during storage tank filling are a major source of spills. Overflows can be prevented. Watch the transfer constantly to prevent overfilling and spilling. Overfill prevention equipment automatically shuts off flow, restricts flow, or sounds an alarm when the tank is almost full. Federal regulations require overfill prevention equipment on all Underground Storage Tanks (USTs) installed after December 1988. For USTs installed before December 1988, overfill prevention equipment is required by 1998. State or local regulations may be stricter, so contact your State and/or local government for details. Consider installing overflow prevention equipment sooner than the required deadline as part of your pollution prevention plan.

FUEL STATION ACTIVITIES THAT CAN CONTAMINATE STORM WATER:

- Spills and leaks that happen during fuel or oil delivery
- Spills caused by "topping off" fuel tanks
- Allowing rainfall on the fuel area or storm water to run onto the fuel area
- Hosing or washing down the fuel area
- Leaking storage tanks

Q. Are vehicle fuel tanks often "topped off"?

Gas pumps automatically shut off when the vehicle fuel tank is almost full to prevent spills. Trying to completely fill the tanks or topping off the tank often results in overfilling the tank and spilling fuel. Discourage topping off by training employees and posting signs.

Q. Have you taken steps to protect fueling areas from rain?

Fueling areas can be designed to minimize spills, leaks, and incidental losses of fuel, such as vapor loss, from coming into contact with rain water:

- Build a roof over the fuel area.
- Pave the fuel area with concrete instead of asphalt. Asphalt soaks up fuel or can be slowly dissolved by fuel, engine fluids, and other organic liquids. Over time, the asphalt itself can become a source of storm water contamination.

Q. Is runoff to the fueling area minimized?

Runoff is storm water generated from other areas that flows or "runs on" to your property or site. Runoff flowing across fueling areas can wash contaminants into storm drains. Runoff can be minimized by:

- Grading, berming, or curbing the area around the fuel site to direct runoff away from the fuel area
- Locating roof downspouts so storm water is directed away from fueling areas
- Using valley gutters to route storm water around fueling area.

Q. Are oil/water separators or oil and grease traps installed in storm drains in the fueling area?

Oil/water separators and oil and grease traps are devices that reduce the amount of oil entering storm drains. These devices should be installed and routinely inspected, cleaned, and maintained.

Q. Is the fueling area cleaned by hosing or washing?

Cleaning the fueling area with running water should be avoided because the wash water will pick up fuel, oil, and grease and make it storm water. Consider using a damp cloth on the pumps and a damp mop on the pavement rather than a hose. Check with your local sewer authority about any treatment required before discharging the mop water or wash water to the sanitary sewer.

Q. Do you control petroleum spills?

Spills should be controlled immediately. Small spills can be contained using sorbent material such as kitty litter, straw, or sawdust. Do not wash petroleum spills into the storm drain or sanitary sewer. For more information on spill control measures, see sections on Containment Diking and Curbing in Chapter 4.

Q. Are employees aware of ways to reduce contamination of storm water at fueling stations?

Storm water contamination from fueling operations often occurs from small actions such as topping off fuel tanks, dripping engine fluids, and hosing down fuel areas. Inform employees about ways to eliminate or reduce storm water contamination.

EMPLOYEE INVOLVEMENT IS THE KEY:

Getting employees interested in reducing waste generation is the key to a successful storm water pollution prevention plan. Discuss pollution prevention with your employees. They are most familiar with the operations that generate wastes and may have helpful waste reduction suggestions. Consider setting up an employee reward program to promote pollution prevention.

Q. Where does the water drain from your fueling area?

In many cases, wash water and storm water in fueling areas drain directly to the storm sewer without adequate treatment. Some types of oil/water separators installed at these locations can provide treatment to discharges from oil contaminated pavements, but this equipment is only effective when properly maintained (i.e., cleaned frequently). Some States require that these discharges be tied in to a sanitary sewer system or process wastewater treatment system. If discharges from fueling or other high risk areas at your facility drain to a sanitary sewer system, you should inform your local POTW.

SUMMARY OF FUELING STATION BMPs

- Consider installing spill and overflow protection.
- Discourage topping off of fuel tanks.
- Reduce exposure of the fuel area to storm water.
- Use dry cleanup methods for the fuel area.
- Use proper petroleum spill control.
- Encourage employee participation.

3.2 BMPs FOR VEHICLE AND EQUIPMENT MAINTENANCE

Many vehicle and equipment maintenance operations use materials or create wastes that are harmful to humans and the environment. Storm water runoff from areas where these activities occur can become polluted by a variety of contaminants such as solvents and degreasing products, waste automotive fluids, oils and greases, acids, and caustic wastes. These and other harmful substances in storm water can enter water bodies through storm drains or through small streams where they can harm fish and wildlife.

The following questions will help you find sources of storm water contamination from vehicle and equipment maintenance operations on your site and to help you choose BMPs that can reduce or eliminate these sources.

Q. Are parts cleaned at your facility?

Parts are often cleaned using solvents such as trichloroethylene, 1,1,1-trichloroethane or methylene chloride. Many of these cleaners are harmful and must be disposed of as a hazardous waste. Cleaning without using liquid cleaners whenever possible reduces waste. Scrape parts with a wire brush, or use a bake oven if one is available. Prevent spills and drips of solvents and cleansers to the shop floor. Do all liquid cleaning at a centralized station so the solvents and residues stay in one area. If you dip parts in liquid, remove them slowly to avoid spills. Locate drip pans, drain boards, and drying racks to direct drips back into a sink or fluid holding tank for reuse.

Q. Have you looked into using nontoxic or less toxic cleaners or solvents?

If possible, eliminate or reduce the number or amount of hazardous materials and waste by substituting nonhazardous or less hazardous materials. For example:

- Use noncaustic detergents instead of caustic cleaning agents for parts cleaning (ask your supplier about alternative cleaning agents).
- Use detergent-based or water-based cleaning systems in place of organic solvent degreasers. Wash water may require treatment before it can be discharged to the sanitary sewer. Contact your local sewer authority for more information.
- Replace chlorinated organic solvents (1,1,1-trichloroethane, methylene chloride, etc.) with nonchlorinated solvents. Nonchlorinated solvents like kerosene or mineral spirits are less

| ACTIVITIES THAT CAN CONTAMINATE STORM WATER: |
|---|
| <p>Engine repair and service:</p> <ul style="list-style-type: none"> • Parts cleaning • Shop cleanup • Spilled fuel, oil, or other materials • Replacement of fluids (oil, oil filters, hydraulic fluids, transmission fluid, and radiator fluids) |
| <p>Outdoor vehicle and equipment storage and parking:</p> <ul style="list-style-type: none"> • Dripping engine and automotive fluids from parked vehicles and equipment |
| <p>Disposal of materials or process wastes:</p> <ul style="list-style-type: none"> • Greasy rags • Oil filters • Air filters • Batteries • Spent coolant, degreasers, etc. |

toxic and less expensive to dispose of but are by no means harmless themselves. Check the list of active ingredients to see whether it contains chlorinated solvents.

- Choose cleaning agents that can be recycled.

Contact your supplier or trade journal for more waste minimization ideas.

Q. Are work areas and spills washed or hosed down with water?

Clean up leaks, drips, and other spills without large amounts of water. Use rags for small spills, a damp mop for general cleanup, and dry absorbent material for larger spills. Consider the following BMPs:

- Avoid hosing down your work areas.
- Collect leaking or dripping fluids in drip pans or containers. If different liquids are kept separate, the fluids are easier to recycle.
- Keep a drip pan under the vehicle while you unclip hoses, unscrew filters, or remove other parts. Use a drip pan under any vehicle that might leak while you work on it to keep splatters or drips off the shop floor.
- Promptly transfer used fluids to the proper waste or recycling drums. Don't leave full drip pans or other open containers lying around
- Locate waste and recycling drums in properly controlled areas of the yard, preferably areas with a concrete slab and secondary containment.

Q. Are spills or materials washed or poured down the drain?

Do not pour liquid waste to floor drains, sinks, outdoor storm drain inlets, or other storm drains or sewer connections. Used or leftover cleaning solutions, solvents, and automotive fluids and oil are often toxic and should not be put into the sanitary sewer. Be sure to dispose of these materials properly or find opportunities for reuse and recycling. If you are unsure of how to dispose of chemical wastes, contact your State hazardous waste management agency or the RCRA hotline at 1-800- 424-9346. Post signs at sinks to remind employees, and paint stencils at outdoor drains to tell customers and others not to pour wastes down drains.

Q. Are oil filters completely drained before recycling or disposal?

Oil filters disposed of in trash cans or dumpsters can leak oil and contaminate storm water. Place the oil filter in a funnel over the waste oil recycling or disposal collection tank to drain excess oil before disposal. Oil filters can be crushed and recycled. Ask your oil supplier or recycler about recycling oil filters.

Q. Are incoming vehicles and equipment checked for leaking oil and fluids?

If possible, park vehicles indoors or under a roof so storm water does not contact the area. If you park vehicles outdoors while they await repair, watch them closely for leaks.

Put pans under leaks to collect fluids for proper recycling or disposal. Keeping leaks off the ground reduces the potential for storm water contamination and reduces cleanup time and costs. If the vehicle or equipment is to be stored outdoors, oil and other fluids should be drained first.

Designate a special area to drain and replace motor oil, coolant, and other fluids, where there are no connections to the storm drain or the sanitary sewer and drips and spills can be easily cleaned up.

Q. Are wrecked vehicles or damaged equipment stored onsite?

Be especially careful with *wrecked vehicles*, whether you keep them indoors or out, as well as with vehicles kept onsite for scrap or salvage. Wrecked or damaged vehicles often drip oil and other fluids for several days.

- As the vehicles arrive, place drip pans under them immediately, even if you believe that all fluids have leaked out before the car reaches your shop.
- Build a shed or temporary roof over areas where you park cars awaiting repairs or salvage, especially if you handle wrecked vehicles. Build a roof over vehicles you keep for parts.
- Drain all fluids, including air conditioner coolant, from wrecked vehicles and "parts" cars. Also drain engines, transmissions, and other used parts.
- Store cracked batteries in a nonleaking secondary container. Do this with all cracked batteries, even if you think all the acid has drained out. If you drop a battery, treat it as if it is cracked. Put it into the containment area until you are sure it is not leaking.

BATTERY ACID SPILLS:

Handle spilled acid from broken batteries with care. If you use baking soda to neutralize spilled acid during cleanup, remember that the residue is still dangerous to handle and must be disposed of as a hazardous waste because it may contain lead and other contaminants.

Q. Do you recycle any of these materials?

- Degreasers
- Used oil or oil filters
- Antifreeze
- Cleaning solutions
- Automotive batteries
- Hydraulic fluid.

All of these materials can be either recycled at your facility or sent offsite for recycling. Some recycling options, ranked by level of effort required, follow.

| |
|--|
| Least Effort: |
| <ul style="list-style-type: none"> • Arrange for collection and transportation of car batteries, used oil and other fluids, cleaning solutions, and degreasers to a commercial recycling facility. This requires that you separate wastes and store them until they are picked up by the recycling company. • "Dirty" solvent can be reused. Presoak dirty parts in used solvent before cleaning the parts in fresh solvent. |
| Moderate Effort: |
| <ul style="list-style-type: none"> • Used oil, antifreeze, and cleaning solutions can be recycled onsite using a filtration system that removes impurities and allows the fluid to be reused. Filtration systems are commercially available. |
| Most Effort: |
| <ul style="list-style-type: none"> • Install an onsite solvent recovery unit. If your facility creates large volumes of used solvents, you may consider purchasing or leasing an onsite still to recover the solvent for reuse. Contact your State hazardous waste management agency for more information about onsite recycling of used solvents. |

Q. Can you reduce the number of different solvents used?

Reducing the number of solvents makes recycling easier and reduces hazardous waste management costs. Often, one solvent can perform a job as well as two different solvents.

Q. Are wastes separated?

Separating wastes allows for easier recycling and may reduce treatment costs. Keep hazardous and non-hazardous wastes separate, do not mix used oil and solvents, and keep chlorinated solvents (like 1,1,1-trichloroethane) separate from nonchlorinated solvents (like kerosene and mineral spirits). Proper labeling of all wastes and materials will help accomplish this goal (see Signs and Labels BMP).

EMPLOYEE INVOLVEMENT IS THE KEY.

Getting employees interested in reducing waste generation is the key to a successful storm water pollution prevention plan. Discuss pollution prevention with your employees. They are most familiar with the operations that generate wastes and may have helpful waste reduction suggestions. Consider setting up an employee reward program to promote pollution prevention.

Q. Do you use recycled products?

Many products made of recycled (i.e., refined or purified) materials are available. Engine oil, transmission fluid, antifreeze, and hydraulic fluid are available in recycled form. Buying recycled products supports the market for recycled materials.

SUMMARY OF VEHICLE MAINTENANCE AND REPAIR BMPs

- Check for leaking oil and fluids.
- Use nontoxic or low-toxicity materials.
- Drain oil filters before disposal or recycling.
- Don't pour liquid waste down drains.
- Recycle engine fluids and batteries.
- Segregate and label wastes.
- Buy recycled products.

3.3 BMPs FOR PAINTING OPERATIONS

Many painting operations use materials or create wastes that are harmful to humans and the environment. Storm water runoff from areas where these activities occur can become polluted by a variety of contaminants such as solvents and dusts from sanding and grinding that contain toxic metals like cadmium and mercury. These and other potentially harmful substances in storm water can enter water bodies directly through storm drains where they can harm fish and wildlife.

The following questions will help you identify potential sources of storm water contamination from painting operations on your site and BMPs that can reduce or eliminate these sources. Reading this section can help you eliminate, reduce, or recycle pollutants that may otherwise contaminate storm water.

Q. Is care taken to prevent paint wastes from contaminating storm water runoff?

Use tarps and vacuums to collect solid wastes produced by sanding or painting. Tarps, drip pans, or other spill collection devices should be used to collect spills of paints, solvents, or other liquid materials. These wastes should be disposed of properly to keep them from contaminating storm water.

PAINTING ACTIVITIES THAT CAN CONTAMINATE STORM WATER:

- Painting and paint removal
- Sanding or paint stripping
- Spilled paint or paint thinner

Q. Are wastes from sanding contained?

Prevent paint chips from coming into contact with storm water. Paint chips may contain hazardous metallic pigments or biocides. You can reduce contamination of storm water with paint dust and chips from sanding by the following practices:

- Avoid sanding in windy weather when possible.
- Enclose outdoor sanding areas with tarps or plastic sheeting. Be sure to provide adequate ventilation and personal safety equipment. After sanding is complete, collect the waste and dispose of it properly.
- Keep workshops clean of debris and grit so that the wind will not carry any waste into areas where it can contaminate storm water.
- Move the activity indoors if you can do so safely.

Q. Are parts inspected before painting?

Inspect the part or vehicle to be painted to ensure that it is dry, clean, and rust free. Paint sticks to dry, clean surfaces, which in turn means a better, longer-lasting paint job.

Q. Are you using painting equipment that creates little waste?

As little as 30 percent of the paint may reach the target from conventional airless spray guns; the rest is lost as overspray. Paint solids from overspray are deposited on the ground where they can contaminate storm water. Other spray equipment that delivers more paint to the target and less overspray should be used:

- Electrostatic spray equipment
- Air-atomized spray guns
- High-volume/low-pressure spray guns
- Gravity-feed guns.

Q. Are employees trained to use spray equipment correctly?

Operator training can reduce overspray and minimize the amount of paint solids that can contaminate storm water. Correct spraying techniques also reduce the amount of paint needed per job. If possible, avoid spraying on windy days. When spraying outdoors, use a drop cloth or ground cloth to collect and dispose of overspray.

Q. Do you recycle paint, paint thinner, or solvents?

These materials can either be recycled at the facility or sent offsite for recycling. Some recycling options ranked by the level of effort required follow.

| |
|---|
| Least Effort: |
| <ul style="list-style-type: none"> • Dirty solvent can be reused for cleaning dirty spray equipment and parts before equipment is cleaned in fresh solvent. • Give small amounts of left-over paint to the customer for touchup. |
| Moderate Effort: |
| <ul style="list-style-type: none"> • Arrange for collection and transportation of paints, paint thinner, or spent solvents to a commercial recycling facility. |
| Most Effort: |
| <ul style="list-style-type: none"> • Install an onsite solvent recovery unit. If your facility creates large volumes of used solvents, paint, or paint thinner, you may consider buying or leasing an onsite still to recover used solvent for reuse. Contact your State hazardous waste management agency for more information about onsite recycling of used solvents. |

Q. Are wastes separated?

Separating wastes makes recycling easier and may reduce treatment costs. Keep hazardous and nonhazardous wastes separate, and keep chlorinated solvents (like 1,1,1-trichloroethane) separate from nonchlorinated solvents (like petroleum distillate and mineral spirits). Check the materials data sheet for ingredients, or talk with your waste hauler or recycling company to learn which waste types can be stored together and which should be separated.

Q. Can you reduce the number of solvents you use?

Reducing the number of solvents makes recycling easier and reduces hazardous waste management costs. Often, one solvent can do a job as well as two different solvents.

Q. Do you use recycled products?

Many products made of recycled (i.e., refined or purified) materials are available. Buying recycled paints, paint thinner, or solvent products helps build the market for recycled materials.

| SUMMARY OF PAINTING OPERATION BMPs |
|--|
| <ul style="list-style-type: none">• Inspect parts prior to painting.• Contain sanding wastes.• Prevent paint waste from contacting storm water.• Proper interim storage of waste paint, solvents, etc.• Evaluate efficiency of equipment.• Recycle paint, paint thinner, and solvents.• Segregate wastes.• Buy recycled products. |

3.4 BMPs FOR VEHICLE AND EQUIPMENT WASHING

Washing vehicles and equipment outdoors or in areas where wash water flows onto the ground can pollute storm water. Wash water can contain high concentrations of oil and grease, phosphates, and high suspended solid loads (these and other potentially harmful substances can pollute storm water when deposited on the ground where they can be picked up by rainfall runoff). Vehicle wash water is considered to be a process wastewater and needs to be covered by an NPDES permit. Contact your permitting authority for information about how vehicle wash water is being regulated in your area.

The following questions are designed to help you find sources of storm water contamination from vehicle and equipment washing and to select BMPs to reduce those sources. Reading this section can help you eliminate, reduce, or recycle pollutants that otherwise may contaminate storm water. Also refer to Vehicle Washing BMP in Section 4.4.

Q. Have you considered using phosphate-free biodegradable detergents?

Phosphates, which are plant nutrients, can cause excessive growth of nuisance plants in water when they enter lakes or streams in wash water. Some States ban the use of detergents containing high amounts of phosphates. Contact your supplier about phosphate-free biodegradable detergents that are available on the market.

VEHICLE AND EQUIPMENT WASHING ACTIVITIES THAT CAN CONTAMINATE STORM WATER:

- Outside equipment or vehicle cleaning (washing or steam cleaning)
- Wash water discharged directly to the ground or storm water drain

Q. Are vehicles, equipment, or parts washed over the open ground?

Used wash water contains high concentrations of solvents, oil and grease, detergents, and metals. Try not to wash parts or equipment outside. Washing over impervious surfaces like concrete, blacktop, or hardpacked dirt allows wash water to enter storm drains directly or deposits contaminants on the ground, where they are washed into storm drains when it rains. Washing over pervious ground such as sandy soils potentially can pollute ground water. Therefore, small parts and equipment washing should be done over a parts washing container where the wash water can be collected and recycled or disposed of properly.

EMPLOYEE INVOLVEMENT IS THE KEY:

Getting employees interested in reducing waste is the key to a successful storm water pollution prevention plan. Discuss pollution prevention with your employees. They are most familiar with the operations that generate wastes and may have helpful waste reduction suggestions. Consider setting up an employee award program to promote pollution prevention.

If you are washing large equipment or vehicles, and have to wash outside, designate a specific area for washing. This area should be bermed to collect the wastewater and graded to direct the wash water to a treatment facility. Consider filtering and recycling vehicle wash water. If recycling is not practical, the wastewater can be discharged to the sanitary sewer. Contact your local sewer authority to find out whether treatment is required before wash water is discharged to the sewer (pretreatment).

SUMMARY OF VEHICLE AND EQUIPMENT WASHING BMPs

- Consider use of phosphate-free detergents.
- Use designated cleaning areas.
- Consider recycling wash water.

3.5 BMPs FOR LOADING AND UNLOADING MATERIALS

Loading/unloading operations usually take place outside on docks or terminals. Materials spilled, leaked, or lost during loading/unloading may collect in the soil or on other surfaces and be carried away by rainfall runoff or when the area is cleaned. Rainfall may wash off pollutants from machinery used to unload or load materials. The following questions are designed to help you find sources of storm water contamination from loading and unloading materials and choose BMPs to reduce or eliminate those sources. Reading this section can start you on the road to eliminating, reducing, or recycling pollutants that otherwise may contaminate storm water. Also refer to the BMP on Loading and Unloading by Air Pressure or Vacuum in Section 4.2.

Q. Are tank trucks and material delivery vehicles located where spills or leaks can be contained?

Loading/unloading equipment and vehicles should be located so that leaks can be contained in existing containment and flow diversion systems.

Q. Is loading/unloading equipment checked regularly for leaks?

Check vehicles and equipment regularly for leaks, and fix any leaks promptly. Common areas for leaks are valves, pumps, flanges, and connections. Look for dust or fumes. These are signs that material is being lost during unloading/loading operations.

LOADING AND UNLOADING ACTIVITIES THAT CAN CONTAMINATE STORM WATER:

- Pumping of liquids or gases from barge, truck or rail car to a storage facility or vice versa
- Pneumatic transfer of dry chemicals to or from the loading and unloading vehicles
- Transfer by mechanical conveyor systems
- Transfer of bags, boxes, drums, or other containers by forklift, trucks, or other material handling equipment

Q. Are loading/unloading docks or areas covered to prevent exposure to rainfall?

Covering loading and unloading areas, such as building overhangs at loading docks, can reduce exposure of materials, vehicles, and equipment to rain.

Q. Are loading/unloading areas designed to prevent storm water runoff?

Runon is storm water created from other areas that flows or "runs on" to your property or site. Runon flowing across loading/unloading areas can wash contaminants into storm drains. Runon can be minimized by:

- Grading, berming, or curbing the area around the loading area to direct runoff away from the area
- Positioning roof down spouts so storm water is directed away from loading sites and equipment and preferably to a grassy or vegetated area where the storm water can soak into the ground.

SUMMARY OF LOADING/UNLOADING OPERATIONS BMPs

- Contain leaks during transfer.
- Check equipment regularly for leaks.
- Limit exposure of material to rainfall.
- Prevent storm water runoff.

3.6 BMPs FOR LIQUID STORAGE IN ABOVE-GROUND TANKS

Accidental releases of chemicals from above-ground liquid storage tanks can contaminate storm water with many different pollutants. Materials spilled, leaked, or lost from storage tanks may accumulate in soils or on other surfaces and be carried away by rainfall runoff. The following questions can help you find sources of storm water contamination from above-ground storage tanks and select BMPs to reduce or eliminate those sources. Also refer of the BMPs listed in Section 4.2 on exposure minimization and Section 4.3 on exposure mitigation for more information.

Q. Do storage tanks contain liquid hazardous materials, hazardous wastes, or oil?

Storage of oil and hazardous materials must meet specific standards set by Federal and State laws. These standards include SPCC plans, secondary containment, installation, integrity and leak detection monitoring, and emergency preparedness plans. Federal regulations set specific standards for preventing runoff and collecting runoff from hazardous waste storage, disposal, or treatment areas. These standards apply to container storage areas and other areas used to store, treat, or dispose of hazardous waste. If the collected storm water is a hazardous waste, it must be managed as a hazardous waste in accordance with all applicable State and Federal environmental regulations. States may also have standards about controlling runoff and runoff from hazardous waste treatment, storage, and disposal areas. To find out more about storage requirements, call the toll-free EPA RCRA hotline at 1-800-424-9346 or contact your State hazardous waste management agency.

THE MOST COMMON CAUSES OF UNINTENTIONAL RELEASES FROM TANKS:

- External corrosion and structural failure
- Installation problems
- Spills and overfills due to operator error
- Failure of piping systems (pipes, pumps, flanges, couplings, hoses, and valves)
- Leaks or spills during pumping of liquids or gases from barges, trucks, or rail cars to a storage facility or vice versa

Q. Are operators trained in correct operating procedures and safety activities?

Well-trained employees can reduce human errors that lead to accidental releases or spills.

Q. Do you have safeguards against accidental releases?

Engineered safeguards can help prevent operator errors that may cause the accidental release of pollutants. Safeguards include:

- Overflow protection devices on tank systems to warn the operator or to automatically shut down transfer pumps when the tank reaches full capacity
- Protective guards around tanks and piping to prevent vehicle or forklift damage
- Clearly tagging or labeling of valves to reduce human error.

Q. Are the tank systems inspected and is tank integrity tested regularly?

Visually inspect the tank system to identify problem areas before they lead to a release. Correct any problems or potential problems as soon as possible. An audit of a newly installed tank system by a registered and specially trained professional engineer can identify and correct potential problems such as loose fittings, poor welding, and improper or poorly fitted gaskets. After installation, have operators visually inspect the tank system on a routine basis. Areas to inspect include tank foundations, connections, coatings, tank walls, and the piping system. Look for corrosion, leaks, straining of tank support structures from leaks, cracks, scratches in protective coatings, or other physical damage that may weaken the tank system. Integrity testing should be done periodically by a qualified professional.

Q. Are tanks bermed or surrounded by a secondary containment system?

A secondary containment system around both permanent and temporary tanks allows leaks to be more easily detected and contains spills or leaks. Methods include berms, dikes, liners, vaults, and double-walled tanks. See Chapter 4 for additional information on containment and spill control.

SUMMARY OF BMPs FOR LIQUID STORAGE IN ABOVE-GROUND TANKS

- Comply with applicable State and Federal laws.
- Properly train employees.
- Install safeguards against accidental releases.
- Routinely inspect tanks and equipment.
- Consider installing secondary containment.

3.7 BMPs FOR INDUSTRIAL WASTE MANAGEMENT AREAS AND OUTSIDE MANUFACTURING

Storm water runoff from areas where industrial waste is stored, treated, or disposed of can be polluted. Outside manufacturing activities can also contaminate storm water runoff. Activities such as rock grinding or crushing, painting or coating, grinding or sanding, degreasing or parts cleaning, or operations that use hazardous materials are particularly dangerous. Wastes spilled, leaked, or lost from waste management areas or outside manufacturing activities may build-up in soils or on other surfaces and be carried away by rainfall runoff. There is also a potential for liquid wastes from lagoons or surface impoundments to overflow to surface waters or soak the soil where they can be picked up by storm water runoff. Possible storm water contaminants include toxic compounds, oil and grease, paints or solvents, heavy metals, and high levels of suspended solids.

The best way to reduce the potential for storm water contamination from both waste management areas and outside manufacturing activities is to reduce the amount of waste that is created and, consequently, the amount that must be stored or treated. The following questions are designed to help you find BMPs that can eliminate or reduce the amount or toxicity of industrial wastes as well as minimize contamination of storm water from existing waste management areas. Waste reduction BMPs are appropriate for a wide range of industries and are designed to provide ideas on ways to reduce wastes. Turn to Appendix D for a list of State and Federal pollution prevention resources that can provide more information and assistance in choosing industrial waste reduction BMPs.

Q. Have you looked for ways to reduce waste at your facility?

The first step to reducing wastes is to assess activities at your facility. The assessment is designed to find situations at your facility where you can eliminate or reduce waste generation, emissions, and environmental damage. The assessment involves steps very similar to those used to develop your Storm Water Pollution Prevention Plan, such as collecting process-specific information; setting pollution prevention targets; and developing, screening, and selecting waste reduction options for further study. Starting a waste reduction program at your facility has many potential benefits. Some of these benefits are direct (e.g., cost savings from reduced raw material use), while others are indirect (e.g., avoided waste disposal fees).

EPA has developed a series of industry-specific pollution prevention waste minimization guidance manuals. The manuals contain steps for assessing your facility's opportunity for reducing waste and describe source reduction and recycling choices. The manuals currently available are listed in Appendix D.

INDUSTRIAL WASTE MANAGEMENT ACTIVITIES OR AREAS THAT CAN CONTAMINATE STORM WATER:

- Landfills
- Waste piles
- Wastewater and solid waste treatment and disposal:
 - Waste pumping
 - Additions of treatment chemicals
 - Mixing
 - Aeration
 - Clarification
 - Solids dewatering
- Land application

Q. Have you considered waste reduction BMPs?

There are many different types of BMPs that can help eliminate or reduce the amount of industrial waste generated at your facility. Some of these BMPs are listed below and referenced in Appendix D.

- Production planning and sequencing
- Process or equipment modification
- Raw material substitution or elimination
- Loss prevention and housekeeping
- Waste segregation and separation
- Closed-loop recycling
- Training and supervision
- Reuse and recycling.

OUTSIDE MANUFACTURING ACTIVITIES OR SITUATIONS THAT CAN CONTAMINATE STORM WATER:

- Processes or equipment that generate dusts, vapors, or emissions
- Outside storage of hazardous materials or raw materials
- Dripping or leaking fluids from equipment or processes
- Liquid wastes discharged directly onto the ground or into the storm sewer

Q. Are industrial waste management and outside manufacturing areas checked often for spills and leaks?

By checking waste management areas for leaking containers or spills, you can prevent wastes from contaminating storm water. Look for containers that are rusty, corroded, or damaged. Transfer wastes from these damaged containers into safe containers. Close the lids on dumpsters to prevent rain from washing wastes out of holes or cracks in the bottom of the dumpster. In outside manufacturing areas, look for leaking equipment (e.g., valves, lines, seals, or pumps) and fix leaks promptly. Inspect rooftop and other outdoor equipment (e.g., HVAC devices, air pollution control devices, transformers, piping, etc.) for leaks or dust concentrations.

Q. Are industrial waste management areas or manufacturing activities covered, enclosed, or bermed?

The best way to avoid contaminating storm water from existing waste management and manufacturing areas is to prevent storm water runoff or rain from entering or contacting these areas. This can be done by:

- Preventing direct contact with rain
- Moving the activity indoors after ensuring that all safety concerns such as fire hazard and ventilation are addressed
- Covering the area with a permanent roof

- Covering waste piles with a temporary covering material such as a reinforced tarpaulin, polyethylene, polyurethane, polypropylene, or Hypalon
- Minimizing storm water runoff by enclosing the area or building a berm around the area.

Q. Are vehicles used to transport wastes to the land disposal or treatment site equipped with anti-spill equipment?

Transport vehicles equipped with spill prevention equipment can prevent spills of wastes during transport. Examples include:

- Vehicles equipped with baffles for liquid wastes
- Trucks with sealed gates and spill guards for solid wastes
- Trucks with tarps.

Q. Do you use loading systems that minimize spills and fugitive losses such as dust or mists?

Wastes lost during loading or unloading can contaminate storm water. Vacuum transfer systems minimize waste loss.

Q. Are sediments or wastes prevented from being tracked offsite?

Wastes and sediments tracked offsite can end up on streets where they are picked up by storm water runoff. This can be avoided by using vehicles with specially designed tires, washing vehicles in a designated area before they leave the site, and controlling the wash water.

Q. Is storm water runoff minimized from the land disposal site?

You can take certain precautions to minimize the runoff of polluted storm water from land application sites. Some precautions are detailed below.

- Choose the land application site carefully. Characteristics that help prevent runoff include slopes under 6 percent, permeable soils, a low water table, locations away from wetlands or marshes, and closed drainage systems.

DO YOU OWN OR OPERATE A HAZARDOUS WASTE TREATMENT, STORAGE, AND DISPOSAL FACILITY?

Federal and State laws establish strict standards for managing solid and hazardous wastes. If you are not sure whether you own or operate a hazardous waste treatment, storage, or disposal facility, call the toll-free EPA RCRA hotline at 1-800-424-9346 or contact your State hazardous waste management agency. Federal regulations contain specific standards about preventing runoff and collecting runoff from hazardous waste storage, disposal, or treatment areas. These standards apply to land treatment units, landfills, waste piles, container storage areas, and other areas used to store, treat, or dispose of hazardous waste. If the collected storm water is a hazardous waste, it must be managed in accordance with all applicable State and Federal environmental regulations. States may also have standards about controlling runoff and runoff from hazardous waste treatment, storage, and disposal areas.

- Avoid applying waste to the site when it is raining or when the ground is frozen or saturated with water. Grow vegetation on areas dedicated to land disposal to stabilize the soils and reduce the volume of surface water runoff from the site.
- Maintain adequate barriers between the land application site and receiving waters.
- Erosion control techniques might include mulching and matting, filter fences, straw bales, diversion terracing, or sediment basins. For a detailed description of erosion control techniques, see Chapter 4.
- Perform routine maintenance to ensure that erosion control or site stabilization measures are working.

**SUMMARY OF INDUSTRIAL WASTE MANAGEMENT AND
OUTSIDE MANUFACTURING BMPs**

- Conduct a waste reduction assessment.
- Institute industrial waste source reduction and recycling BMPs.
- Prevent runoff and runoff from contacting the waste management area.
- Minimize runoff from land application sites.

3.8 BMPs FOR OUTSIDE STORAGE OF RAW MATERIALS, BY-PRODUCTS, OR FINISHED PRODUCTS

Raw materials, by-products, finished products, containers, and material storage areas exposed to rain and/or runoff can pollute storm water. Storm water can become contaminated by a wide range of contaminants (e.g., metals, oil, and grease) when solid materials wash off or dissolve into water, or by spills or leaks. The following questions are designed to help you identify potential sources of storm water contamination and select BMPs that can reduce or eliminate those sources. Reading this section can help you eliminate or reduce pollutants that otherwise may contaminate storm water.

Q. Are materials protected from rainfall, runoff, and runoff?

The best way to avoid contaminating storm water from outside material storage areas is to prevent storm water runoff or rain from coming in contact with the materials. This can be done by:

- Storing the material indoors
- Covering the area with a roof
- Covering the material with a temporary covering made of polyethylene, polyurethane, polypropylene, or Hypalon.
- Minimizing storm water runoff by enclosing the area or building a berm around the area.

ARE ANY OF THESE MATERIALS STORED OUTSIDE OR IN AREAS WHERE THEY CAN CONTAMINATE STORM WATER?

- Fuels
- Raw materials
- By-products
- Intermediates
- Final products
- Process residuals

SUMMARY OF BMPs FOR OUTSIDE STORAGE OF RAW MATERIALS, BY-PRODUCTS, OR FINISHED PRODUCTS

- Cover or enclose materials.

3.9 BMPs FOR SALT STORAGE FACILITIES

Salt left exposed to rain or snow can be lost. Salt spilled or blown onto the ground during loading and unloading will dissolve in storm water runoff. Storm water contaminated with salt can be harmful to vegetation and aquatic life. Salty storm water runoff soaking into the ground may contaminate ground water and make it unsuitable as a drinking water supply. The following BMPs will help reduce storm water contamination from salt storage and transfer activities. See Chapter 4 for more detailed information on covering storage areas.

Q. Are salt piles protected from rain?

The best way to prevent salt from contaminating storm water is to eliminate or limit the exposure of salt to rain. Preventing contact with rain also protects against salt loss and prevents salt from absorbing moisture and becoming caked or lumpy and making it difficult to handle and use.

- Store salt under a roof. This is the best way to stop direct contact with rain.

If salt must be stored outside:

- Build the storage pile on asphalt to reduce the potential for ground water contamination
- Cover the pile with a temporary covering material such as polyethylene, polyurethane, polypropylene, or Hypalon.

Q. Is storm water runoff prevented from contacting storage piles and loading and unloading areas?

Storm water runoff can be minimized by enclosing the area or building berms around storage, loading, and unloading areas.

SALT STORAGE ACTIVITIES THAT CAN CONTAMINATE STORM WATER:

- Salt stored outside in piles or bags that are exposed to rain or snow
- Salt loading and unloading areas located outside or in areas where spilled salt can contaminate storm water.

SUMMARY OF SALT STORAGE FACILITIES BMPs

- Put it under a roof.
- Use temporary covers.
- Enclose or berm transfer areas.

CHAPTER

4

SITE-SPECIFIC INDUSTRIAL STORM WATER BMPs

This chapter describes some of the possible Best Management Practices (BMPs) that you might include in your Storm Water Pollution Prevention Plan so that pollutants from your site do not mix with storm water.

Table 4.1 provides an easy index of the BMP descriptions that follow. The BMPs are grouped by section into six categories: Flow Diversion Practices; Exposure Minimization Practices; Mitigative Practices; Other Preventive Practices; Sediment and Erosion Prevention Practices; and Infiltration Practices.

The following information is provided for each BMP: (1) description of the BMP; (2) when and where the BMP can be used; (3) factors that should be considered when using the BMP; and (4) advantages and disadvantages of the BMP. More detailed fact sheets for a limited number of the Sediment and Erosion Prevention Practices are included as Appendix E. When designing these structural controls, EPA recommends that you refer to any State or local storm water management design standards.

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4.1 FLOW DIVERSION PRACTICES

Structures that divert stream flow (such as gutters, drains, sewers, dikes, and graded pavement) are used as BMPs in two ways. First, flow diversion structures, called storm water conveyances, may be used to channel storm water away from industrial areas so that pollutants do not mix with the storm water. Second, they also may be used to carry pollutants directly to a treatment facility. This section briefly describes flow diversion as a BMP for industrial storm water.

Storm Water Conveyances (Channels/Gutters/Drains/Sewers)

What Are They

Storm water conveyances such as channels, gutters, drains, and sewers, collect storm water runoff and direct its flow. A group of connecting conveyances is sometimes installed at an industrial facility to create a storm water collection system. Storm water conveyances can be used for two different purposes. The first purpose is to keep uncontaminated storm water from coming in contact with areas of an industrial site where it may become contaminated with pollutants. This can be accomplished by collecting the storm water in a conveyance and by changing the direction of flow away from those areas. The second purpose is to collect and carry the storm water that has already come into contact with industrial areas and become contaminated to a treatment facility.

Storm water conveyances can be constructed or lined with many different materials, including concrete, clay tiles, asphalt, plastics, metals, riprap, compacted soils, and vegetation. The type of material used depends on the use of the conveyance. These conveyances can be temporary or permanent.

When and Where to Use Them

Storm water conveyances work well at most industrial sites. Storm water can be directed away from industrial areas by collecting it in channels or drains before it reaches the areas. In addition, conveyances can be used to collect storm water downhill from industrial areas and keep it separate from runoff that has not been in contact with those areas. When potentially contaminated storm water is collected in a conveyance like this, it can be directed to a treatment facility on the site if necessary. (If a pollutant is spilled, it should not be allowed to enter a storm water conveyance or drain system.)

What to Consider

In planning for storm water conveyances, consider the amount and speed of the typical storm water runoff. Also, consider the patterns in which the storm water drains so that the channels may be located to collect the most flow and can be built to handle the amount of water they will receive. When deciding on the type of material for the conveyance, consider the resistance of the material, its durability, and compatibility with any pollutants it may carry.

Conveyance systems are most easily installed when a facility is first being constructed. Use of existing grades will decrease costs. Grades should be positive to allow for the continued movement of the runoff through the conveyance system; however, grades should not create an increase in velocity that causes an increase in erosion (this will also depend upon what materials the conveyance is lined with and the types of outlet controls that are provided).

Ideally, storm water conveyances should be inspected to remove debris within 24 hours of rainfall, or daily during periods of prolonged rainfall, since heavy storms may clog or damage them. It is important to repair damages to these structures as soon as possible.

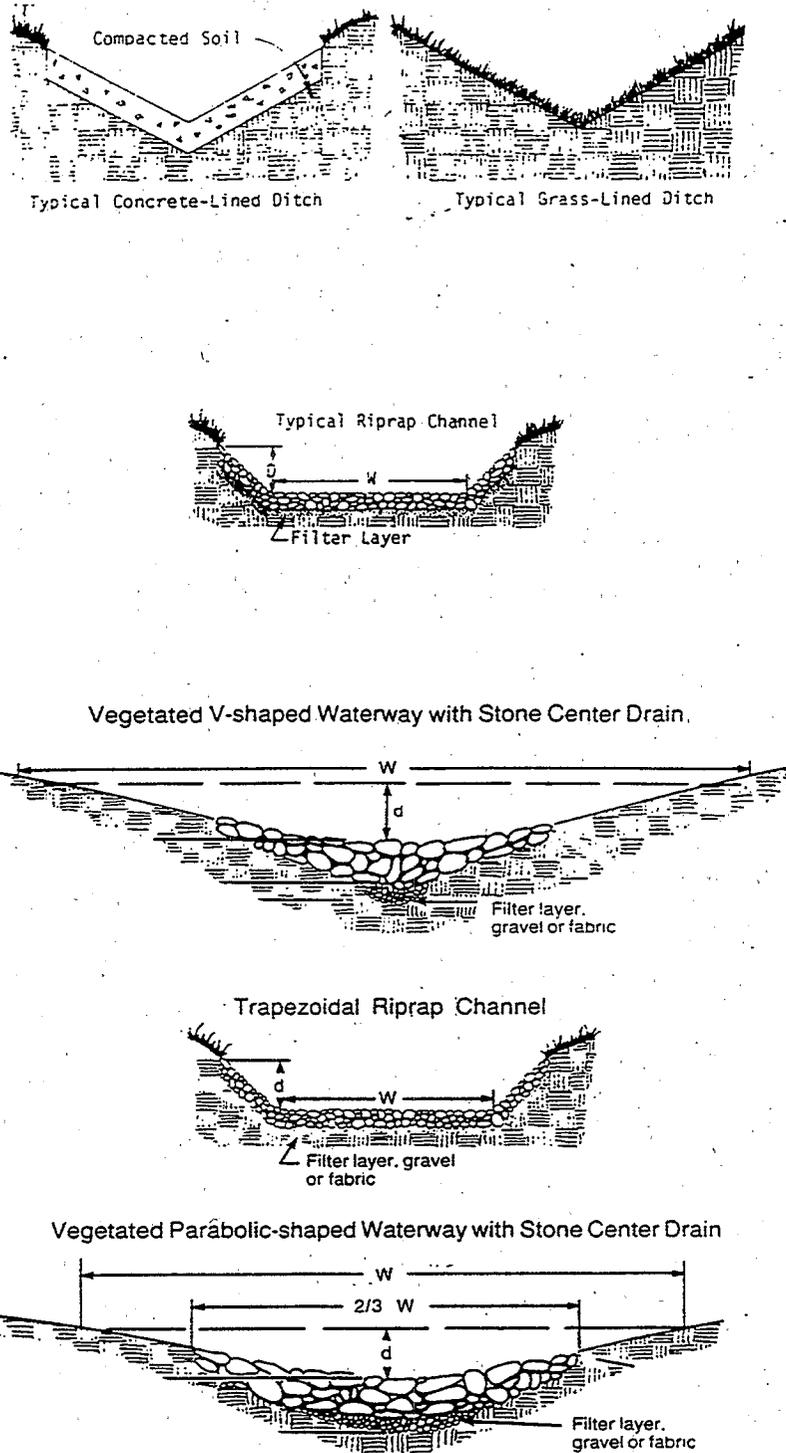


FIGURE 4.1 TYPICAL STORM WATER CONVEYANCE CROSS SECTIONS
(Modified from Commonwealth of Virginia, 1980)

Advantages of Storm Water Conveyances (Channels/Gutters/Drains/Sewers)

- Direct storm-water flows around industrial areas
- Prevent temporary flooding of industrial site
- Require low maintenance
- Provide erosion resistant conveyance of storm water runoff
- Provide long-term control of storm water flows

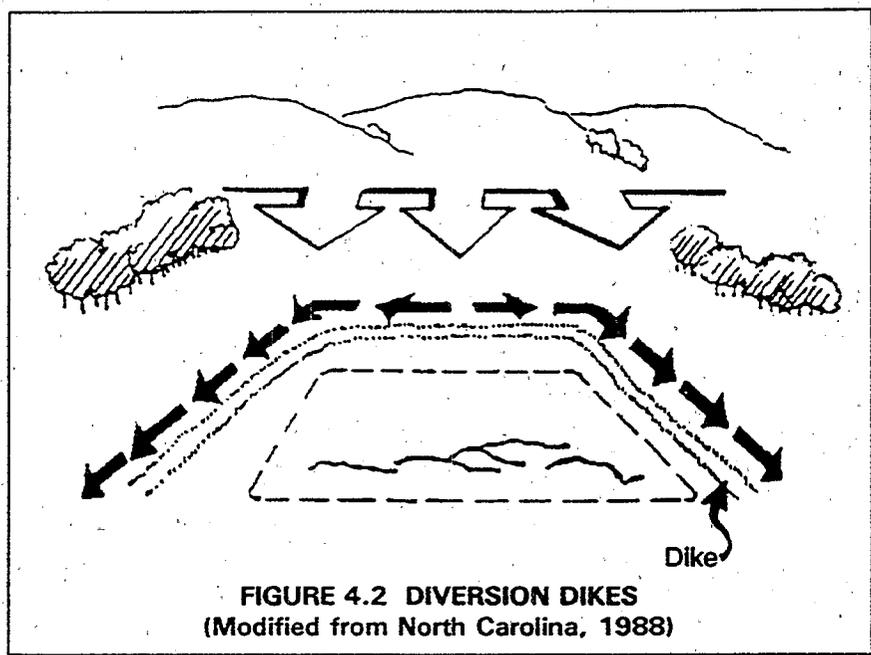
Disadvantages of Storm Water Conveyances (Channels/Gutters/Drains/Sewers)

- Once flows are concentrated in storm water conveyances, they must be routed through stabilized structures all the way to their discharge to the receiving water or treatment plant to minimize erosion
- May increase flow rates
- May be impractical if there are space limitations
- May not be economical, especially for small facilities or after a site has already been constructed

Diversion Dikes

What Are They

Diversion dikes or berms are structures used to block runoff from passing beyond a certain point. Temporary dikes are usually made with compacted soil. More permanent ridges are constructed out of concrete, asphalt, or similar materials.



When and Where to Use Them

Diversion dikes are used to prevent the flow of storm water runoff onto industrial areas. Limiting the volume of flow across industrial areas reduces the volume of storm water that may carry pollutants from the area, requiring treatment for pollutant removal. This BMP is suitable for industrial sites where significant volumes of storm water runoff tend to flow onto active industrial areas. Typically, dikes are built on slopes just uphill from an industrial area together with some sort of a conveyance such as a swale. The storm water conveyance is necessary to direct the water away from the dike so that the water will not pool and seep through the dike.

What to Consider

In planning for the installation of dikes, consider the slope of the drainage area, the height of the dike, the size of rainfall event it will need to divert, and the type of conveyance that will be used with the dike. Steeper slopes result in higher volumes of runoff and higher velocities; therefore, the dike must be constructed to handle this situation. Remember that dikes are limited in their ability to manage large volumes of runoff.

Ideally, dikes are installed before industrial activity begins. However, dikes can be easily constructed at any time. Temporary dikes (usually made of dirt) generally only last for 18 months or less, but they can be made into permanent structures by stabilizing them with vegetation. Vegetation is crucial for preventing the erosion of the dike.

Dikes should be inspected regularly for damage. This is especially important after storm events since a heavy rain may wash parts of a temporary dike away. Any necessary repairs should be made immediately to make sure the structure continues to do its job.

| Advantages of Diversion Dikes |
|---|
| <ul style="list-style-type: none">• Effectively limit storm water flows over industrial site areas• Can be installed at any time• Are economical temporary structures, when built from soil onsite• Can be converted from temporary to permanent at any time |
| Disadvantages of Diversion Dikes |
| <ul style="list-style-type: none">• Are not suitable for large drainage areas unless there is a gentle slope• May require maintenance after heavy rains |

Graded Areas and Pavement

What Is It

Land surfaces can be graded or graded and paved so that storm water runoff is directed away from industrial activity areas. The slope of the grade allows the runoff to flow, but limits the runoff from washing over areas that may be contaminated with pollutants. Like conveyances and dikes, graded areas can prevent runoff from contacting industrial areas and becoming contaminated with pollutants from these areas. Grading can be a permanent or temporary control measure.

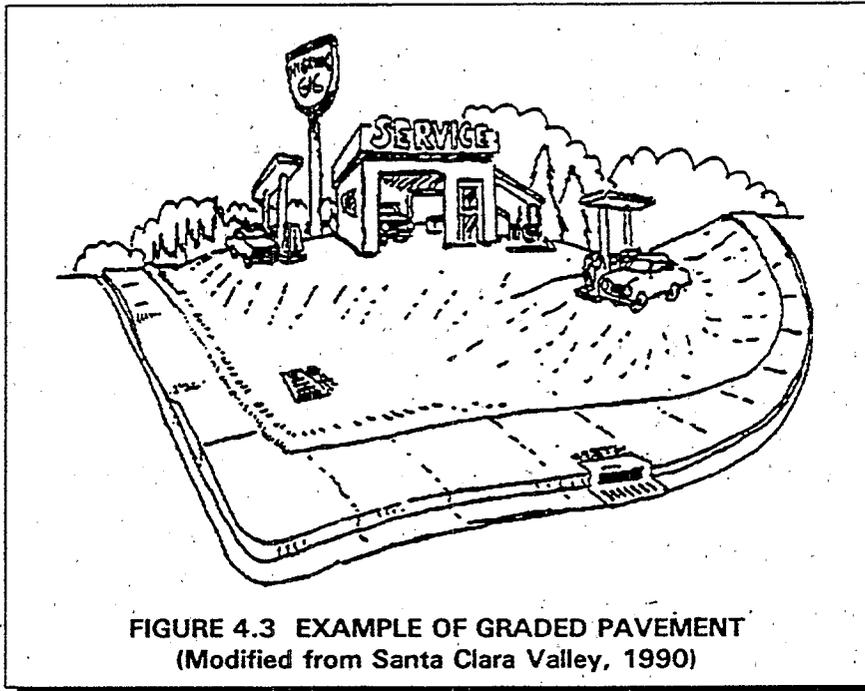


FIGURE 4.3 EXAMPLE OF GRADED PAVEMENT
(Modified from Santa Clara Valley, 1990)

When and Where to Use It

Grading land surfaces is appropriate for any industrial site that has outdoor activities that may contaminate storm water runoff, such as parking lots or outdoor storage areas. Figure 4.3 illustrates the use of graded pavement in preventing runoff from washing over a service station site. Grading is often used with other practices, such as coverings, buffer zones, and other practices to reduce the runoff velocity and provide infiltration of the uncontaminated runoff, or to direct pollutant runoff to storm water treatment facilities.

What to Consider

When designing graded areas and pavement, both control and containment of runoff flows should be considered. The grading should control the uncontaminated flow by diverting it around areas

that may have pollutants. The grading should also contain the contaminated flows or divert them to treatment facilities.

When regrading and paving an industrial area, the use of concrete paving instead of asphalt should be considered. This is especially important in potential spill sites or hazardous material storage areas. Asphalt absorbs organic pollutants and can be slowly dissolved by some fluids, thus becoming a possible source of contaminants itself. This control measure should be used with a cover, such as a roof, in areas where contaminants are of concern (see Covering BMP) so that rain or snow does not fall on the area and wash the contaminants down slope.

Inspect paving regularly for cracks that may allow contaminants to seep into the ground. Also, check to make sure that the drains receiving the storm water flow from the paved area remain unclogged with sediment or other debris so that low areas do not flood and wash over the areas where the contaminants may be.

| |
|---|
| Advantages of Graded Areas and Pavement |
| <ul style="list-style-type: none">• Is effective in limiting storm water contact with contaminants• Is relatively inexpensive and easily implemented |
| Disadvantages of Graded Areas and Pavement |
| <ul style="list-style-type: none">• May be uneconomical to regrade and resurface large areas• May not be effective during heavy precipitation |

4.2 EXPOSURE MINIMIZATION PRACTICES

By eliminating or minimizing the possibility of storm water coming into contact with pollutants, facilities can eliminate or minimize the contamination of storm water discharges associated with their industrial activity. As a result, fewer materials will be carried away by storm water runoff, the costs of collecting and treating contaminated storm water will be decreased, and safety and environmental liabilities that result from spills and leaks will be reduced.

Completely eliminating the exposure of materials to storm water is not always possible, however. For many industrial facilities, enclosure of facility grounds is not technologically or economically possible. Therefore, this section describes several simple and inexpensive structural and nonstructural BMPs that a facility can use to minimize the exposure of materials to storm water.

Containing spills is one of the primary methods of minimizing exposure of contaminants to storm water runoff. Spill containment is used for enclosing any drips, overflows, leaks, or other liquid material releases, as well as for isolating and keeping pollutant spills away from storm water runoff.

There are numerous spill containment methods, ranging from large structural barriers to simple, small drip pans. The benefits of each of these practices vary based on cost, need for maintenance, and size of the spill they are designed to control. This section describes several containment methods, including:

- Containment Diking
- Curbing
- Drip Pans
- Catch Basins
- Sumps.

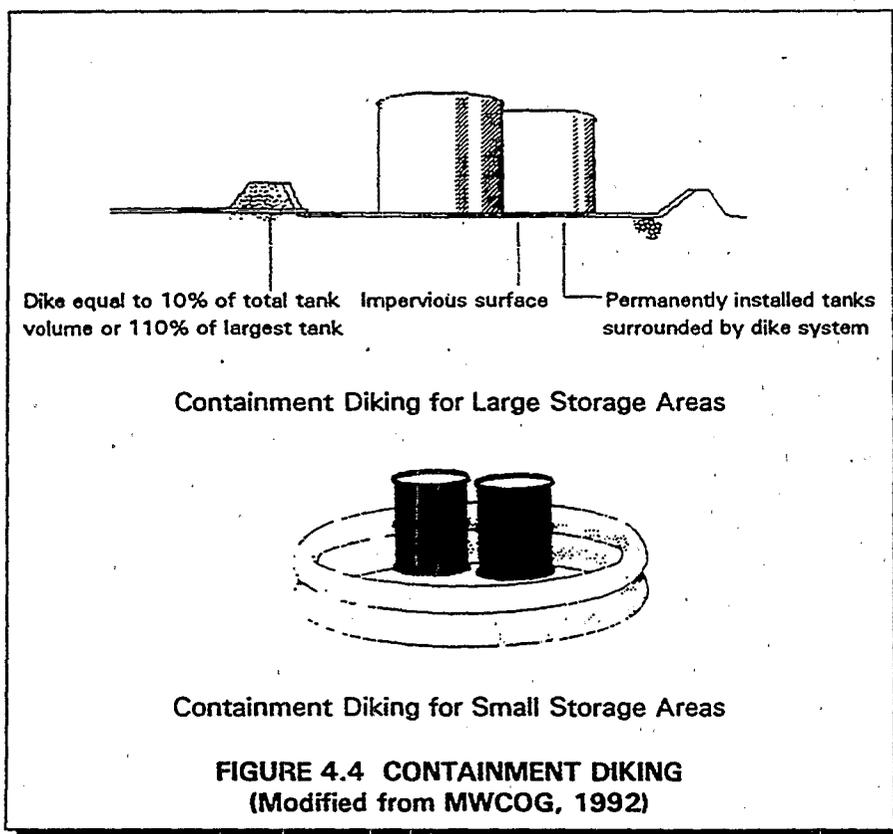
Other practices commonly used to minimize exposure of contaminants are also discussed, including the following:

- Covering
- Vehicle Positioning
- Loading and Unloading by Air Pressure or Vacuum.

Containment Diking

What Is It

Containment dikes are temporary or permanent earth or concrete berms or retaining walls that are designed to hold spills. Diking, one of the most common types of containment, is an effective method of pollution prevention for above-ground liquid storage tanks and rail car or tank truck loading and unloading areas. Diking can provide one of the best protective measures against the contamination of storm water because it surrounds the area of concern and holds the spill, keeping spill materials separated from the storm water outside of the diked area.



When and Where to Use It

Diking can be used at any industrial facility but is most commonly used for controlling large spills or releases from liquid storage areas and liquid transfer areas.

What to Consider

Containment dikes should be large enough to hold an amount equal to the largest single storage tank at the particular facility plus the volume of rainfall. For rail car and tank truck loading and unloading operations, the diked area should be capable of holding an amount equal to any single

tank truck compartment. Materials used to construct the dike should be strong enough to safely hold spilled materials. The materials used usually depend on what is available onsite and the substance to be contained, and may consist of earth (i.e., soil or clay), concrete, synthetic materials (liners), metal, or other impervious materials. In general, strong acids and bases may react with metal containers, concrete, and some plastics, so where spills may consist of these substances, other alternatives should be considered. Some of the more reactive organic chemicals may also need to be contained with special liners. If there are any questions about storing chemicals in certain dikes because of their construction materials, refer to the Material Safety Data Sheets (MSDSs).

Containment dikes may need to be designed with impervious materials to prevent leaking or contamination of storm water, surface, and ground water supplies.

Similarly, uncontrolled overflows from diked areas containing spilled materials or contaminated storm water should be prevented to protect nearby surface waters or ground waters. Therefore, dikes should have either pumping systems (see Sumps BMP) or vacuum trucks available to remove the spilled materials. When evaluating the performance of the containment system, you should pay special attention to the overflow system, since it is often the source of uncontrolled leaks. If overflow systems do not exist, accumulated storm water should be released periodically. Contaminated storm water should be treated prior to release. Mechanical parts, such as pumps or even manual systems (e.g., slide gates, stopcock valves), may require regular cleaning and maintenance.

When considering containment diking as a BMP, you should consult local authorities about any regulations governing construction of such structures to comply with local and State requirements. Facilities located in a flood plain should contact their local flood control authority to ensure that construction of the dikes is permitted.

Inspections of containment dikes should be conducted during or after significant storms or spills to check for washouts or overflows. In addition, regular checks of containment dikes (i.e., testing to ensure that dikes are capable of holding spills) is recommended. Soil dikes may need to be inspected on a more frequent basis.

Changes in vegetation, inability of the structure to retain storm water dike erosion, or soggy areas indicate problems with the dike's structure. Damaged areas should be patched and stabilized immediately, where necessary. Earthen dikes may require special maintenance of vegetation, such as mowing and irrigation.

| Advantages of Containment Diking |
|--|
| <ul style="list-style-type: none"> • Contains spills, leaks, and other releases and prevent them from flowing into runoff conveyances, nearby streams, or underground water supplies • Permits materials collected in dikes to be recycled • Is a common industry practice for storage tanks and already required for certain chemicals |
| Disadvantages of Containment Diking |
| <ul style="list-style-type: none"> • May be too expensive for some smaller facilities • Requires maintenance • Could collect contaminated storm water, possibly resulting in infiltration of storm water to ground water |

Curbing

What Is It

Like containment diking, curbing is a barrier that surrounds an area of concern. Curbing functions in a similar way to prevent spills, leaks, etc. from being released to the environment by routing runoff to treatment or control areas. The terms curbing and diking are sometimes used interchangeably.

Because curbing is usually small-scale, it cannot contain large spills like diking can, however, curbing is common at many facilities in small areas where handling and transferring liquid materials occur.

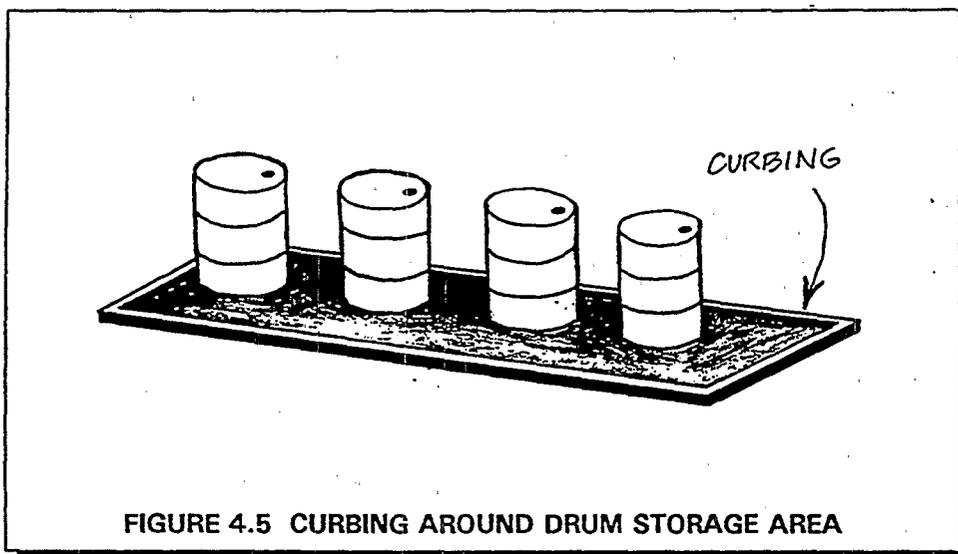


FIGURE 4.5 CURBING AROUND DRUM STORAGE AREA

When and Where to Use It

Curbing can be used at all industrial facilities. It is particularly useful in areas where liquid materials are transferred and as a storm water runoff control.

As with diking, common materials for curbing include earth, concrete, synthetic materials, metal, or other impenetrable materials. Asphalt is also a common material used in curbing.

What to Consider

For maximum efficiency of curbing, spilled materials should be removed immediately, to allow space for future spills. Curbs should have pumping systems, rather than drainage systems, for collecting spilled materials. Manual or mechanical methods, such as those provided by sump systems (see Sump BMP), can be used to remove the material. Curbing systems should be maintained through curb repair (patching and replacement).

When using curbing for runoff control, facilities should protect the berm by limiting traffic and installing reinforced berms in areas of concern.

Spills of materials that are stored within a curbed area can be tracked outside of that area when personnel and equipment leave the area. This tracking can be minimized by grading within the curbing to direct the spilled materials to a down-slope side of the curbing. This will keep the materials away from personnel and equipment that pass through the area. It will also allow the materials to accumulate in one area making cleanup much easier.

Inspections should also be conducted before forecasted rainfall events and immediately after storm events. If spilled or leaked materials are observed, cleanup should start immediately. This will prevent overflows and/or contamination of storm water runoff. In addition, prompt cleanup of materials will prevent dilution by rainwater, which can adversely affect recycling opportunities. Inspection of curbed areas should be conducted regularly, to clear clogging debris. Because curbing is sized to contain small spill volumes, maintenance should also be conducted frequently to prevent overflow of any spilled materials.

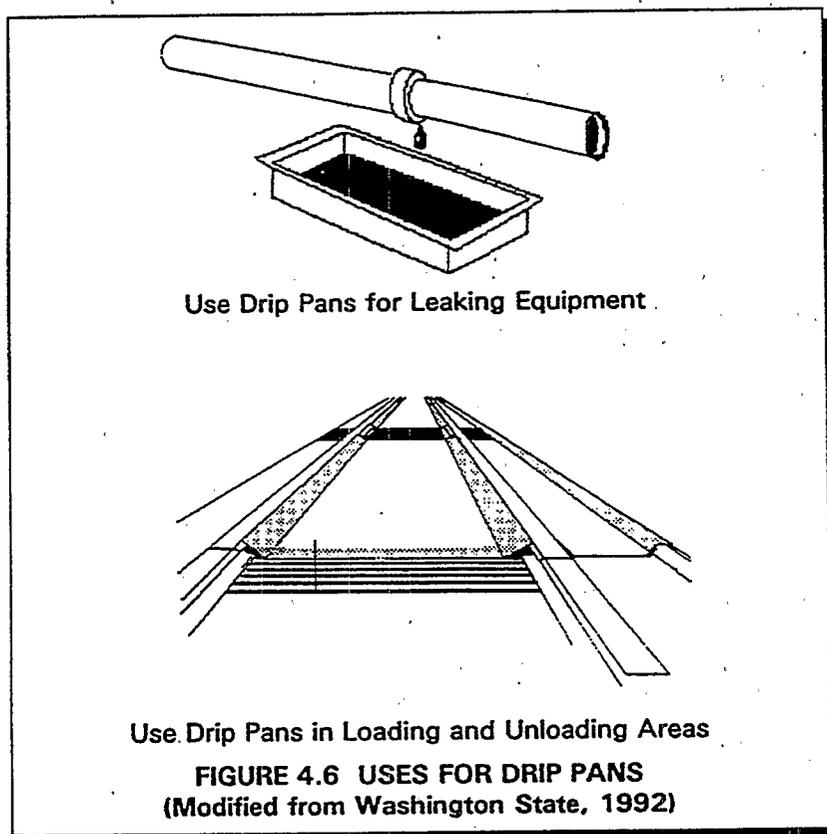
| Advantages of Curbing |
|--|
| <ul style="list-style-type: none">• Is an excellent method to control <u>runon</u>• Is inexpensive• Is easily installed• Materials spilled within curbed areas can be recycled• Exists as a common industry practice |
| Disadvantages of Curbing |
| <ul style="list-style-type: none">• Is not effective for holding large spills• May require more maintenance than diking |

Drip Pans

What Are They

Drip pans are small depressions or pans used to contain very small volumes of leaks, drips, and spills that occur at a facility. Drip pans can be depressions in concrete, asphalt, or other impenetrable materials or they can be made of metals, plastic, or any material that does not react with the dripped chemicals. Drip pans can be temporary or permanent.

Drip pans are used to catch drips from valves, pipes, etc. so that the materials or chemicals can be cleaned up easily or recycled before they can contaminate storm water. Although leaks and drips should be repaired and eliminated as part of a preventive maintenance program, drip pans can provide a temporary solution where repair or replacement must be delayed. In addition, drip pans can be an added safeguard when they are positioned beneath areas where leaks and drips may occur.



When and Where to Use Them

Drip pans can be used at any industry where valves and piping are present and the potential for small volume leakage and dripping exist.

What to Consider

When using drip pans, consider the location of the drip pan, weather conditions, the type of material to be used for the drip pan, and how it will be cleaned.

The location of the drip pan is important. Because drip pans must be inspected and cleaned frequently, they must be easy to reach and remove. In addition, take special care to avoid placing drip pans in precarious positions such as next to walkways, on uneven pavement/ground, or sitting on pipelines. Drip pans in these locations are easily overturned and may present a safety hazard, as well as an environmental hazard.

Weather conditions are also important factors. Heavy winds and rainfall move or damage drip pans because of their small size and their light weight (if not built-in). To prevent this, secure the pans by installing or anchoring them. Drip pans may be placed on platforms or behind wind blocks or tied down.

For drip pans to be effective, employees must pay attention to the pans and empty them when they are nearly full. Because of their small holding capacities, drip pans will easily overflow if not emptied. Also, recycling efforts can be affected if storm water accumulates in drip pans and dilutes the spilled material. It is important to have clearly specified and easily followed practices of reuse/recycle and/or disposal, especially the disposal of hazardous materials. Many facilities dump the drip pan contents into a nearby larger volume storage container and periodically recycle the contents of the storage container.

In addition, frequent inspection of the drip pans is necessary due to the possibility of leaks in the pan itself or in piping or valves that may occur randomly or irregular slow drips that may increase in volume. Conduct inspections before forecasted rainfall events to remove accumulated materials and immediately after storm events to empty storm water accumulations.

| Advantages of Drip Pans |
|---|
| <ul style="list-style-type: none"> • Are inexpensive • Are easily installed and simple to operate • Allow for reuse/recycle of collected material • Empty or discarded containers may be reused as drip pans |
| Disadvantages of Drip Pans |
| <ul style="list-style-type: none"> • Contain small volumes only • Must be inspected and cleaned frequently • Must be secured during poor weather conditions • Contents may be disposed of improperly unless facility personnel are trained in proper disposal methods |

Collection Basins

What Are They

Collection basins, or storage basins, are permanent structures where large spills or contaminated storm water are contained and stored before cleanup or treatment. Collection basins are designed to receive spills, leaks, etc. that may occur and prevent these materials from being released to the environment. Unlike containment dikes, collection basins can receive and contain materials from many locations across a facility.

Collection basins are commonly confused with treatment units such as ponds, lagoons, and other containment structures. Collection basins differ from these structures because they are designed to temporarily store storm water rather than treat it.

When and Where to Use Them

Collection basins are appropriate for all industrial sites where space allows. Collection basins are particularly useful for areas that have a high spill potential.

What to Consider

The design and installation considerations for collection basins include sizing the basin either to hold a certain amount of spill or a certain size storm, or both. In designing the collection system, the type of material for the conveyances, compatibility of various materials to be carried through the system, and requirements for compliance with State and local regulations should be considered. Ideally, the system should function to route the materials quickly and easily to the collection basin.

When spills occur, the collection system must route the spill or storm water immediately to the collection basin. After a spill is contained, the collection system and basin may require cleaning. Remove the collection basin contents immediately to prevent an unintentional release and recycle the spilled material as much as possible. Inspect the structure on a regular basis and after storm events or spills. Depending upon the types of pollutants that may be in the storm water, or are collected as spills, design of the basin may require a liner to prevent infiltration into the ground water. Make sure that the installation of this BMP does not violate State ground water regulations.

If it is possible that the collection basin may handle combustible or flammable spilled materials, explosion-proof pumping equipment and controls or other appropriate precautions should be taken to prevent explosions or fires. Consult OSHA and local safety codes and standards for specific requirements and guidance.

| Advantages of Collection Basins |
|--|
| <ul style="list-style-type: none">• Can store contaminated storm water until directed to a treatment facility• Can collect spills for recycling where materials are separated |
| Disadvantages of Collection Basins |
| <ul style="list-style-type: none">• May need a conveyance system for increased effectiveness• May collect materials that are not compatible• May reduce the potential for recycling materials by collecting storm water, which dilutes the materials• May create ground water problems if pollutants infiltrate into ground |

Sumps

What Are They

Sumps are holes or low areas that are structured so that liquid spills or leaks will flow down toward a particular part of a containment area. Frequently, pumps are placed in a depressed area and are turned on automatically to transfer liquids away from the sump when the level of liquids gets too high. Sumps can be temporary or permanent.

When and Where to Use Them

Sumps can be used at all facilities. Sumps are used with other spill containment and treatment measures and can be located almost anywhere onsite. Sumps are frequently located in low lying areas within material handling or storage areas.

What to Consider

When designing and installing a sump system, consider the pump location, function, and system alarms. Design and install the sump in the lowest lying area of a containment structure, allowing for materials to gather in the area of the sump. Construct the sump of impenetrable materials and provide a smooth surface so that liquids are funneled toward the pump. It may be appropriate to house the pumps in a shed or other structure for protection and stabilization.

There are numerous factors that should be considered when purchasing a pump. Base the size of the pump on the maximum expected volume to be collected in the containment structure. In some cases, more than one pump may be appropriate. Typically, pumps that can be submerged under the spill are the most appropriate for areas where large spills may occur and that may submerge the sump area. The viscosity (thickness) of the material and the distance that the material must be pumped are also important considerations. Install pumps according to the manufacturer's recommendations.

An alarm system can be installed for pumps that are used to remove collected materials. An alarm system can indicate that a pump should be operated by hand or that an automatically operated pump has failed to function. Ultimately, facility personnel should have some mechanism to take action to prevent spills from by-passing and overflowing containment structures.

The pumps and the alarm system used in the sump generally require regular inspections for service and maintenance of parts based on manufacturers' recommendations.

If it is possible that the sump may handle combustible or flammable spilled materials, explosion-proof pumping equipment and controls or other appropriate precautions should be taken to prevent explosions or fires. Consult OSHA and local safety codes and standards for specific requirements and guidance.

| Advantages of Sumps |
|--|
| <ul style="list-style-type: none">• Provide a simple and quick collection method for recycling, reusing, or treating materials in a containment structure• Are commonly used at industrial facilities |
| Disadvantages of Sumps |
| <ul style="list-style-type: none">• Pumps may clog easily if not designed correctly• May require maintenance/servicing agreements with pump dealers• Costs for purchasing and/or replacing pumps may be high |

Covering

What Is It

Covering is the partial or total physical enclosure of materials, equipment, process operations, or activities. Covering certain areas or activities prevents storm water from coming into contact with potential pollutants and reduces material loss from wind blowing. Tarpaulins, plastic sheeting, roofs, buildings, and other enclosures are examples of covering that are effective in preventing storm water contamination. Covering can be temporary or permanent.

When and Where to Use It

Covering is appropriate for outdoor material storage piles (e.g., stockpiles of dry materials, gravel, sand, compost, sawdust, wood chips, de-icing salt, and building materials) and areas where liquids and solids in containers are stored or transferred. Although it may be too expensive to cover or enclose all industrial activities, cover high-risk areas (identified during the storm water pollutant source identification). For example, cover chemical preparation areas, vehicle maintenance areas, areas where chemically treated products are stored, and areas where salts are stored.

If covering or enclosing the entire activity is not possible, the high-risk part of the activity can often be separated from other processes and covered. Another option that reduces the cost of building a complete enclosure is to build a roof over the activity. A roof may also eliminate the need for ventilation and lighting systems (Washington State, 1992).

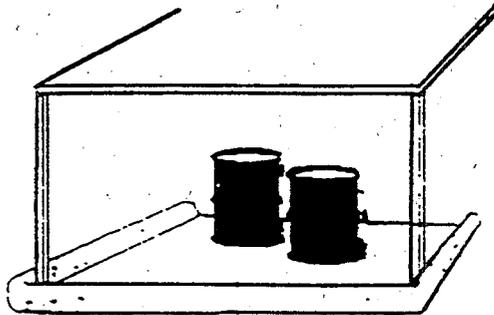
What to Consider

Evaluate the strength and longevity of the covering, as well as its compatibility with the material or activity being enclosed. When designing an enclosure, consider access to materials, their handling, and transfer. Materials that pose environmental and safety dangers because they are radioactive, biological, flammable, explosive, or reactive require special ventilation and temperature considerations.

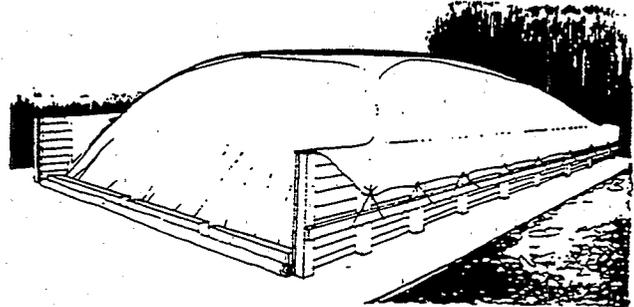
Covering alone may not protect exposed materials from storm water contact. Place the material on an elevated, impermeable surface or build curbing around the outside of the materials to prevent problems from runoff of uncontaminated storm water from adjacent areas.

Frequently inspect covering, such as tarpaulins, for rips, holes, and general wear. Anchor the covering with stakes, tie-down ropes, large rocks, tires, or other easily available heavy objects.

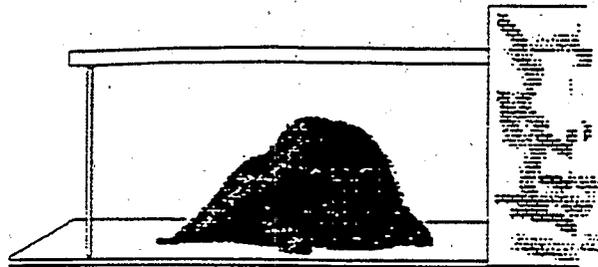
Practicing proper materials management within an enclosure or underneath a covered area is essential. For example, floor drainage within an enclosure should be properly designed and connected to the wastewater sewer where appropriate and allowed. If connection to an offsite wastewater sewer is considered, the local Publicly Owned Treatment Works (POTW) should be consulted to find out if there are any pretreatment requirements or restrictions that must be followed.



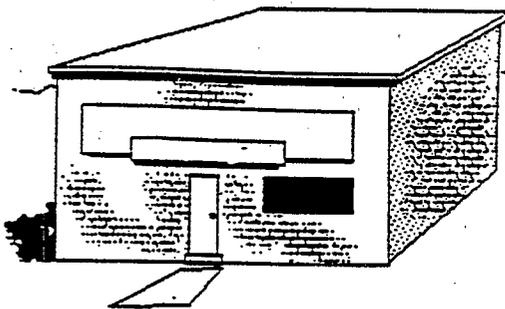
Small Chemical Storage Area with Curbing and Cover



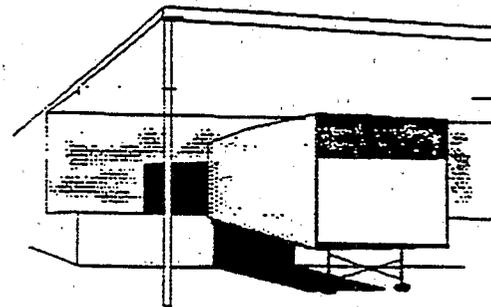
Raw Material Storage Covered with Tarpaulin



Covered Area for Raw Materials



Enclosed Area for Storage of Raw Materials or Chemicals



Covered Area for Loading and Unloading

FIGURE 4.7 EXAMPLE COVERING FOR INDUSTRIAL ACTIVITIES
(Modified from Washington State, 1992; Salt Institute, 1987)

| Advantages of Covering |
|---|
| <ul style="list-style-type: none">• Is simple and effective• Is commonly inexpensive |
| Disadvantages of Covering |
| <ul style="list-style-type: none">• Requires frequent inspection• May pose health or safety problems if enclosure is built over certain activities |

Vehicle Positioning

What Is It

Vehicle positioning is the practice of locating trucks or rail cars while transferring materials to prevent spills of materials onto the ground surface, which may then contaminate storm water runoff. Vehicle positioning is a simple and effective method of material spill prevention and yet it is commonly overlooked.

When and Where to Use It

Vehicle positioning can be used at all types of industrial facilities. This practice is appropriate for any area where materials are transferred from or to vehicles, such as loading and unloading areas, storage areas, and material transfer areas. Use vehicle positioning in conjunction with other practices such as covering, sumps, drip pans, or loading and unloading by air pressure or vacuum where chemical spills are of concern.

What to Consider

The purpose of vehicle positioning is to locate vehicles in a stable and appropriate position to prevent problems, such as spills resulting from broken material storage containers, spills caused by vehicle movement during materials transfer activities, and spills caused by improperly located vehicles. Vehicles should also be positioned near containment or flow diversion systems to collect unexpected spills from leaks in transfer lines or connections. The following activities are included in this practice:

- Constructing walls that help in positioning the vehicles
- Positioning vehicle either over a drain or on a sloped surface that drains to a containment structure
- Outlining required vehicle positions on the pavement
- Using wheel guards or wheel blocks
- Posting signs requiring the use of emergency brakes
- Requiring vehicles to shut off engines during materials transfer activities.

Advantages of Vehicle Positioning

- Is inexpensive
- Is easy and effective

Disadvantages of Vehicle Positioning

- May require redesign of loading and unloading areas

Loading and Unloading by Air Pressure or Vacuum

What Is It

Air pressure and vacuum systems are commonly used for transporting and loading and unloading materials. These systems are simple to use and effective in transferring dry chemicals or solids from one area to another, but are less effective as the particles of material become more dense.

In an air pressure system, a safety-relief valve and a dust collector are used to separate the dry materials from the air and then release the air accumulated during transfer operations. In a vacuum system, a dust collection device and an air lock, such as a rotary gate or trap door feeder, are typically used.

The use of mechanical equipment that involves enclosed lines, such as those provided by air pressure (also referred to as pneumatic) and vacuum loading systems, are effective methods for minimizing releases of pollutants into the environment. Because of the enclosed nature of the system, pollutants are not exposed to wind or precipitation and therefore have less potential to contaminate storm water discharges.

When and Where to Use It

Air pressure and vacuum systems can be used at all types of industrial facilities. This equipment is located in material handling areas to use for storing, loading and unloading, transporting, or conveying materials.

What to Consider

Unlike many of the other BMPs discussed in this manual, air pressure and vacuum systems may be expensive because of the costs of purchasing the system and retrofitting the system to existing materials handling procedures. In many cases, these systems can be shipped to a facility and be installed onsite without contractor help. Manufacturer's recommendations should be followed closely to ensure proper installation. In other cases, systems may have to be designed specifically for a site. Proper design and installation are very important for air pressure and vacuum systems to be as effective as possible. The equipment may be weatherproof or, if not, consider enclosing or covering the equipment.

Conduct routine inspections of air pressure and vacuum systems. Regular maintenance is required of these systems, especially the dust collectors. Conduct maintenance activities based on manufacturers' recommendations. Inspect air pressure systems more frequently due to the greater potential for leaks to the environment.

Advantages of Loading and Unloading by Air Pressure or Vacuum

- Is quick and simple
- May be economical if materials can be recovered
- Will minimize exposure of pollutants to storm water

Disadvantages of Loading and Unloading by Air Pressure or Vacuum

- May be costly to install and maintain
- May not be appropriate for some denser materials
- May require site-specific design
- Dust collectors may need a permit under the Clean Air Act to install

4.3 MITIGATIVE PRACTICES

Mitigation involves cleaning up or recovering a substance after it has been released or spilled to reduce the potential impact of a spill before it reaches the environment. Therefore, pollution mitigation is a second line of defense where pollution prevention practices have failed or are impractical. Because spills cannot always be avoided at industrial sites, it is necessary to plan for these events and to design proper response procedures. This section discusses mitigative BMPs to avoid contamination of storm water. Most of the mitigative practices discussed are simple and should be incorporated in your facility's good housekeeping and spill response plans. The mitigation practices discussed include manual cleanup methods, such as sweeping and shoveling, mechanical cleanup by excavation or vacuuming, and cleanup with sorbents and gels.

Facilities are cautioned that spills of certain toxic and hazardous substances and their cleanup may be covered under regulations, including those imposed under the Superfund Amendments and Reauthorization Act (SARA), the Comprehensive Environmental Responsibility, Compensation, and Liability Act (CERCLA), and the Resource Conservation and Recovery Act (RCRA).

Sweeping

What Is It

Sweeping with brooms, squeegees, or other mechanical devices is used to remove small quantities of dry chemicals and dry solids from areas that are exposed to precipitation or storm water runoff. These areas may include dust or contaminant covered bags, drums containing remaining materials on their lids, areas housing enclosed or covered materials, and spills of dry chemicals and dry solids in locations on the industrial site. Cleaning by sweeping with brooms is a low cost practice that can be performed by all employees and requires no special equipment or training.

When and Where to Use It

Sweeping can be used at many material handling areas and process areas in all types of industrial facilities. Timing is an important consideration for all mitigative practices. To be effective as a storm water control, cleanup must take place before rainfall or contact with storm water runoff or before an outside area is hosed down.

Do not limit your cleanup activities to those outside activities that are exposed to rainfall. In many cases, tracking of materials to the outside from areas that are enclosed or covered (e.g., on shoes) may also occur.

What to Consider

Store brooms appropriately and do not expose them to precipitation. In addition, rules of compatibility also apply. Do not use the same broom to clean up two chemicals that are incompatible. Determine the compatibility between the brooms themselves and the chemical of concern before using this practice. In some instances, chemicals should be vacuumed instead of swept. Be sure that swept material is disposed of properly.

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|--|
| Advantages of Sweeping |
| <ul style="list-style-type: none"> • Is inexpensive • Requires no special training • Provides recycling opportunities |
| Disadvantages of Sweeping |
| <ul style="list-style-type: none"> • Is a labor-intensive practice • Is limited to small releases of dry materials |

Shoveling

What Is It

Shoveling is another manual cleanup method that is simple and low in cost. Generally, shoveling can be used to remove larger quantities of dry chemicals and dry solids, as well as to remove wetter solids and sludge. Shoveling is also useful in removing accumulated materials from sites not accessible by mechanical cleanup methods.

When and Where to Use It

Shoveling can be used at any facility. Shoveling provides an added advantage over sweeping because cleanup methods are not limited to dry materials. In many cases, accumulated solids and sludges that are in ditches, sumps, or other facility locations can be effectively and quickly removed by shoveling.

Shovels can also be used to clean up contaminated snows. Timing is an important consideration in any mitigative practice. Materials that could contaminate storm water runoff should be removed before any storm event.

What to Consider

As with brooms, clean and store shovels properly. Also, consider planning for the transport and disposal or reuse of the shoveled materials.

Advantages of Shoveling

- Is inexpensive
- Provides recycling opportunities
- Can remediate larger releases and is effective for dry and wet materials

Disadvantages of Shoveling

- Is labor-intensive
- Is not an appropriate practice for large spills

Excavation Practices

What Are They

Excavation (i.e., removal of contaminated material) of released materials is typically conducted by mechanical equipment, such as plows and backhoes. Generally, plowing and backhoeing can be done using a specifically designed vehicle, tractor, or truck.

Excavation removes the materials of concern and any deposition of contaminants, thereby reducing the potential for storm water contamination. Mechanical cleanup methods are typically less precise than manual cleanup methods, resulting in reduced opportunities for recycle and reuse.

When and Where to Use Them

Excavation practices are most useful for large releases of dry materials and for areas contaminated by liquid material releases. In excavation, you want to be sure that all of the contaminated material is removed.

Timing is an important consideration for all mitigative practices. To be effective as a storm water control, cleanup must take place before a rainfall event.

What to Consider

Conduct inspections and operations and maintenance in accordance with a manufacturer's recommendations, which may include the following:

- A specified frequency for inspection, maintenance, and servicing of the equipment
- Parts replacement, rotation, and lubrication specifications
- Procedures for evaluating all parts.

As with any equipment used during cleanup, other considerations apply, including the following:

- Plows, backhoes, etc. should be stored appropriately with no exposure to precipitation
- Excavated materials should be properly handled or disposed of.

Advantages of Excavation Practices

- Are a cost effective method for cleaning up dry materials release
- Are common and simple

Disadvantages of Excavation Practices

- Are less precise, resulting in less recycling and reuse opportunities

Vacuum and Pump Systems

What Are They

Vacuum and pump systems are effective for cleaning up spilled or exposed materials.

The benefits of vacuum and pump cleanup systems include simplicity and speed. With such systems, only the spilled materials need be collected. Also, these systems are often portable and can be used at many locations to clean up releases to the environment. Portable systems can usually be rented.

When and Where to Use Them

Vacuum and pump systems can be used at any industrial facility. Both wet and dry materials can be collected with these systems. Vacuum systems can be used in material handling areas and process areas.

What to Consider

Consider the area of use and the most appropriate size for the system. Since these systems can be portable, size is important, especially if materials will be stored in the unit. In this case, the portable system must have enough suction or positive air pressure to transport materials over long distances. Include plans for proper disposal or reuse of the collected materials.

Advantages of Vacuum and Pump Systems

- Remove materials by air pressure or vacuum quickly and simply
- Collect materials accurately
- Offer good recycling opportunities

Disadvantages of Vacuum and Pump Systems

- May require high initial capital cost
- Require equipment maintenance

Sorbents

What Are They

Sorbents are materials that are capable of cleaning up spills through the chemical processes of adsorption and absorption. Sorbents adsorb (an attraction to the outer surface of a material) or absorb (taken in by the material like a sponge) only when they come in contact with the sorbent materials. The sorbents must be mixed with a spill or the liquid must be passed through the sorbent. Sorbent materials come in many different forms from particles to foams. Often the particles are held together in structures called booms, pads, or socks. Sorbents include, but are not limited to, the following:

- **Common Materials (clays, sawdust, straw, and flyash)**—Generally come in small particles that can be thrown onto a spill that is on a surface. The materials absorb the spill by taking up the liquid.
- **Polymers (polyurethane and polyolefin)**—Come in the form of spheres, beads, or foam tablets. These materials absorb a chemical spill by taking up the liquid into their open-pore structure.
- **Activated Carbon**—Comes in a powdered or granular form and can be mixed with liquids to remove pollutants. This sorbent works by adsorbing the organics to its surface and can be recycled and then reused by a process called regeneration.
- **"Universal Sorbent Material"**—Is a silicate glass foam consisting of rounded particles that can absorb the material.

When and Where to Use Them

Sorbents are useful BMPs for facilities with liquid materials onsite. Timing is important for these practices. To be effective as a storm water BMP, cleanup must take place before a rainfall. Sorbents are often used in conjunction with curbing to provide cleanup of small spills within a containment area.

"Universal Sorbent Materials" are suitable for use on many compounds including acids, alkalis, alcohols, aldehydes, arsenate, ketones, petroleum products, and chlorinated solvents.

Activated carbon is useful for adsorbing many organic compounds. Organics that are diluted in water can be passed through a column that is filled with the activated carbon material to remove the organics, or the activated carbon can be mixed into the water and can then be filtered out.

Polyurethane is good with chemical liquids such as benzene, chlorinated solvents, epichlorhydrin, and phenol. Polyolefin is used to remove organic solvents, such as phenol and various chlorinated solvents. The beads and spheres are usually mixed into a spill by use of a blower and then are skimmed from the top surface by use of an oil boom.

More common materials such as clay, sawdust, straw, and fly-ash can be used for a liquid spill on a surface that is relatively impenetrable, and are usually spread over the spill area with shovels.

Booms, pads, and socks are also useful in areas where there are small liquid spills or drips or where small amounts of solids may mix with small amounts of storm water runoff. They can function

both to absorb the pollutants from the storm water and restrict the movement of a spill. Socks are often used together with curbing to clean up small spills.

What to Consider

Because sorbents work by a chemical or physical reaction, some sorbents are better than others for certain types of spills. Therefore, the use of sorbents requires that personnel know the properties of the spilled material(s) to know which sorbent is appropriate. To be effective, sorbents must adsorb the material spilled but must not react with the spilled material to form hazardous or toxic substances. Follow the manufacturers' recommendations.

For sorbents to be effective, they must be applied immediately in the release area. The use of sorbent material is generally very simple: the sorbent is added to the area of release, mixed well, and allowed to adsorb or absorb. Many sorbents are not reusable once they have been used. Proper disposal is required.

| Advantages of Sorbents |
|---|
| <ul style="list-style-type: none">• Work in water environments (booms and socks)• Offer recycling opportunities (some types of sorbents) |
| Disadvantages of Sorbents |
| <ul style="list-style-type: none">• Require a knowledge of the chemical makeup of a spill (to choose the best sorbent)• Offer no recycling opportunities (some types of sorbents)• May be expensive practice for large spills• May create disposal problems and increase disposal costs by creating a solid waste and potentially a hazardous waste. |

Gelling Agents

What Are They

Gelling agents are materials that interact with liquids either physically or chemically (i.e., thickening or polymerization). Some of the typical gelling agents are polyelectrolytes, polyacrylamide, butylstyrene copolymers, polyacrylonitrile, polyethylene oxide, and a gelling agent referred to as the universal gelling agent which is a combination of these synthetics.

Gelling interacts with a material by concentrating and congealing it to become semisolid. The semisolid gel later forms a solid material, which can then be cleaned up by manual or mechanical methods. The BMP of using a gelling agent is one of the few ways to effectively control a liquid spill before it reaches a receiving water or infiltrates into the soil and then ground water.

When and Where to Use Them

Gelling agents are useful for facilities with significant amounts of liquid materials stored onsite. Gels cannot be used to clean up spills on surface water unless authorized by the U.S. Coast Guard or EPA Regional Response Team.

What to Consider

Gels can be used to stop the liquid's flow on land, prevent its seeping into the soil, and reduce the surface spreading of a spill. Because of these properties, gels can reduce the need for extensive cleanup methods and reduce the possibility of storm water contamination from an uncontrolled industrial spill. As with sorbents, the use of gels simply involves the addition of the gel to the area of the spill, mixing well, and allowing the mass to congeal. To use gels correctly, however, personnel need to know the properties of the spilled materials so that they can choose the correct gel.

Timing is particularly important for gelling agent use. To prevent the movement of materials, gelling agents must be applied immediately after the spill. The use of gelling agents results in a large bulk of congealed mass that usually cannot be separated. Ultimately, this mass will need to be cleaned up by manual or mechanical methods and disposed of properly.

| Advantages of Gelling Agents |
|--|
| <ul style="list-style-type: none">• Stop the movement of spilled or released liquid materials• Require no permanent structure |
| Disadvantages of Gelling Agents |
| <ul style="list-style-type: none">• May require knowledge of the spilled materials to select correct gelling agents• Usually offer no recycling opportunities• May be difficult to clean up• May create disposal problems and increase disposal costs by creating a solid waste and potentially a hazardous waste |

4.4 OTHER PREVENTIVE PRACTICES

A number of preventive measures can be taken at industrial sites to limit or prevent the exposure of storm water runoff to contaminants. This section describes a few of the most easily implemented measures:

- Preventive Monitoring Practices
- Dust Control (Land Disturbance and Demolition Areas)
- Dust Control (Industrial)
- Signs and Labels
- Security
- Area Control Procedures
- Vehicle Washing.

Preventive Monitoring Practices

What Are They

Preventive monitoring practices include the routine observation of a process or piece of equipment to ensure its safe performance. It may also include the chemical analysis of storm water before discharge to the environment.

When and Where to Use Them

Automatic Monitoring System—In areas where overflows, spills, and catastrophic leaks are possible, an automatic monitoring system is recommended. Some Federal, State, and local laws require such systems to be present if threats exist to the health and safety of personnel and the environment. For material management areas, monitoring may include liquid level detectors, pressure and temperature gauges, and pressure-relief devices. In material transfer, process, and material handling areas, automatic monitoring systems can include pressure drop shutoff devices, flow meters, thermal probes, valve position indicators, and operation lights. Loading and unloading operations might use these devices for measuring the volume of tanks before loading, for weighing vehicles or containers, and for determining rates of flow during loading and unloading.

Automatic Chemical Monitoring—Measures the quality of plant runoff to determine whether discharge is appropriate or whether diversion to a treatment system is warranted. Such systems might monitor pH, turbidity, or conductivity. These parameters might be monitored in diked areas, sewers, drainage ditches, or holding ponds. Systems can also be designed to signal automatic diversion of contaminated storm water runoff to a holding pond (e.g., a valve or a gate could be triggered by a certain pollutant in the storm water runoff).

Manned Operations—In material transfer areas and process areas, personnel can be stationed to watch over the operations so that any spills or mismanagement of materials can be corrected immediately. This is particularly useful at loading and unloading areas where vehicles or equipment must be maneuvered into the proper position to unload (see Vehicle Positioning BMP).

Nondestructive Testing—Some situations require that a storage tank or a pipeline system be tested without being physically moved or disassembled. The structural integrity of tanks, valves, pipes, joints, welds, and other equipment can be tested using nondestructive methods. Acoustic emission tests use high frequency sound waves to draw a picture of the structure to reveal cracks, malformations, or other structural damage. Another type of testing is hydrostatic pressure testing. During pressure testing, the tank or pipe is subjected to pressures several times the normal pressure. A loss in pressure during the testing may indicate a leak or some other structural damage. Tanks and containers should be pressure tested as required by Federal, State, or local regulations.

What to Consider

Automated monitoring systems should be placed in an area where plant personnel can easily observe the measurements. Alarms can be used in conjunction with the measurement display to warn personnel. Manned operations should have communication systems available for getting help in case spills or leaks occur. Especially sensitive or spill-prone areas may require back-up instrumentation in case the primary instruments malfunction.

Mechanical and electronic equipment should be operated and maintained according to the manufacturers' recommendations. Equipment should be inspected regularly to ensure proper and accurate operation. _

The pollution prevention team, in consultation with a certified safety inspector, should evaluate system monitoring requirements to decide which systems are appropriate based on hazard potential.

| Advantages of Preventive Monitoring Practices |
|--|
| <ul style="list-style-type: none">• Pressure and vacuum testing can locate potential leaks or damage to vessels early. The primary benefit of such testing is in ensuring the safety of personnel, but it also has secondary benefits including prevention of storm water contamination.• Automatic system monitors allow for early warnings if a leak, overflow, or catastrophic incident is imminent.• Manning operations, especially during loading and unloading activities, is effective and generally inexpensive.• The primary benefit of nondestructive testing is in ensuring the safety of personnel, but it also has secondary benefits including early detection of the potential for contaminating storm water runoff. |
| Disadvantages of Preventive Monitoring Practices |
| <ul style="list-style-type: none">• Plant personnel often do not have the expertise to maintain automatic equipment.• Automatic equipment can fail without warning.• Automated process control and monitoring equipment may be expensive to purchase and operate |

Dust Control (Land Disturbance and Demolition Areas)

What Is It

Dust controls for land disturbance and demolition areas are any controls that reduce the potential for particles being carried through air or water. Types of dust control are:

- **Irrigation**—Irrigation is a temporary measure involving a light application of water to moisten the soil surface. The process should be repeated as necessary.
- **Minimization of Denuded Areas**—Minimizing soil exposure reduces the amount of soil available for transport and erosion. Soil exposure can be lessened by temporary or permanent soil stabilization controls, such as seeding, mulching, topsoiling, crushed stone or coarse gravel spreading, or tree planting. Maintaining existing vegetation on a site will also help control dust.
- **Wind Breaks**—Wind breaks are temporary or permanent barriers that reduce airborne particles by slowing wind velocities (slower winds do not suspend particles). Leaving existing trees and large shrubs in place will create effective wind breaks. More temporary types of wind breaks are solid board fences, snow fences, tarp curtains, bales of hay, crate walls, and sediment walls.
- **Tillage**—Deep plowing will roughen the soil surface to bring up to the surface cohesive clods of soil, which in turn rest on top of dusts, protecting them from wind and water erosion. This practice is commonly practiced in arid regions where establishing vegetation may take time.
- **Chemical Soil Treatments (palliatives)**—These are temporary controls that are applied to soil surfaces in the form of spray-on adhesives, such as anionic asphalt emulsion, latex emulsion, resin-water emulsions, or calcium chloride. The palliative is the chemical used. These should be used with caution as they may create pollution if not used correctly.

When and Where to Use It

Dust controls can be used on any site where dust may be generated and where the dust may cause onsite and offsite damage. Dust controls are especially critical in arid areas, where reduced rainfall levels expose soil particles for transport by air and runoff. This control should be used in conjunction with other sedimentation controls such as sediment traps.

What to Consider

To control dust during land disturbance and at demolition areas, exposure of soil should be limited as much as possible. When possible, work that causes soil disturbance or involves demolition should be done in phases and should be accompanied by temporary stabilization measures. These precautions will minimize the amount of soil that is disturbed at any one time and, therefore, control dust.

Oil should not be used to control dust because of its high potential for polluting storm water discharges.

Irrigation will be most effective if site drainage systems are checked to ensure that the right amount of water is used. Too much water can cause runoff problems.

Chemical treatment is only effective on mineral soils, as opposed to muck soils, because the chemicals bond better to mineral soils. Therefore, it should be used only in arid regions. Vehicular traffic should be routed around chemically treated areas to avoid tracking of the chemicals. Certain chemicals may be inappropriate for some types of soils or application areas. For example, spraying chemicals on the soil of an industrial site adjacent to a school may be dangerous. Local governments usually have information about restrictions on the types of palliatives that may be used. Special consideration must be given to preserving ground water quality whenever chemicals are applied to the land.

Since most of these techniques are temporary controls, sites should be inspected often and materials should be reapplied when needed. The frequency for these inspections depends on site-specific conditions, weather conditions, and the type of technique used.

Advantages of Dust Control (Land Disturbance and Demolition Areas)

- Can help prevent wind-and-water based erosion of disturbed areas and will reduce respiratory problems in employees
- Some types can be implemented quickly at low cost and effort (except wind breaks)
- Helps preserve the aesthetics of the site and screens certain activities from view (wind breaks)
- Vegetative wind breaks are permanent and an excellent alternative to chemical use

Disadvantages of Dust Control (Land Disturbance and Demolition Areas)

- Some types are temporary and must be reapplied or replenished regularly
- Some types are expensive (irrigation and chemical treatment) and may be ineffective under certain conditions
- May result in health and/or environmental hazards, e.g., if overapplication of the chemicals leaves large amounts exposed to wind and rain erosion or ground water contamination
- May create excess runoff that the site was not designed to control (irrigation)
- May cause increased offsite tracking of mud (irrigation)
- Is not as effective as chemical treatment or mulching and seeding; requires land space that may not be available at all locations (wind breaks)

Dust Control (Industrial)

What Is It

Dust controls for material handling areas are controls that prevent pollutants from entering storm water discharges by reducing the surface and air transport of dust caused by industrial activities. Consider the following types of controls:

- Water spraying
- Negative pressure systems (vacuum systems)
- Collector systems (bag and cyclone)
- Filter systems
- Street sweeping.

The purpose of industrial dust control is to collect or contain dusts to prevent storm water runoff from carrying the dusts to the sewer collection system or to surface waters.

When and Where to Use It

Dust control is useful in any process area, loading and unloading area, material handling areas, and transfer areas where dust is generated. Street sweeping is limited to areas that are paved.

What to Consider

Mechanical dust collection systems are designed according to the size of dust particles and the amount of air to be processed. Manufacturers' recommendations should be followed for installation (as well as the design of the equipment).

If water sprayers are used, dust-contaminated waters should be collected and taken for treatment. Areas will probably need to be resprayed to keep dust from spreading.

Two kinds of street sweepers are common: brush and vacuum. Vacuum sweepers are more efficient and work best when the area is dry.

Mechanical equipment should be operated according to the manufacturers' recommendations and should be inspected regularly.

Advantages of Dust Control (Industrial)

- May cause a decrease of respiratory problems in employees around the site
- May cause less material to be lost and may therefore save money
- Provides efficient collection of larger dust particles (street sweepers)

Disadvantages of Dust Control (Industrial)

- Is generally more expensive than manual systems
- May be impossible to maintain by plant personnel (the more elaborate equipment)
- Is labor and equipment intensive and may not be effective for all pollutants (street sweepers)

Signs and Labels

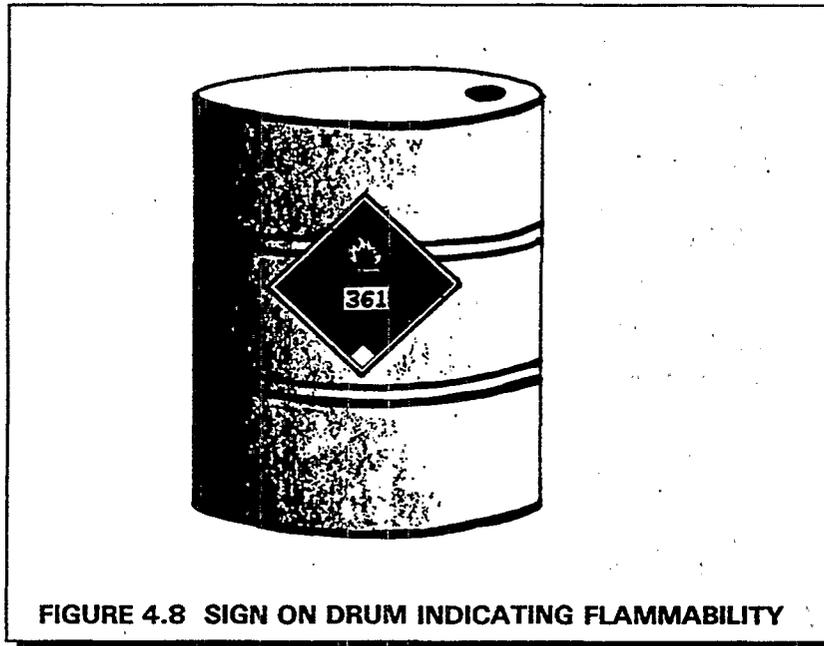
What Are They

Signs and labels identify problem areas or hazardous materials at a facility. Warning signs, often found at industrial facilities, are a good way to suggest caution in certain areas. Signs and labels can also provide instructions on the use of materials and equipment. Labelling is a good way to organize large amounts of materials, pipes, and equipment, particularly on large sites.

Labels tell material type and container contents. Accurate labeling can help facilities to quickly identify the type of material released so facility personnel can respond correctly.

Two effective labeling methods include color coding and Department of Transportation (DOT) labeling. Color coding is easily recognized by facility personnel and simply involves painting/coating or applying an adhesive label to the container. Color codes must be consistent throughout the facility to be effective, and signs explaining the color codes should be posted in all areas.

DOT requires that labels be prominently displayed on transported hazardous and toxic materials. Labeling required by DOT could be expanded to piping and containers, making it easy to recognize materials that are corrosive, radioactive, reactive, flammable, explosive, or poisonous.



When and Where to Use Them

Signs and labels can be used at all types of facilities. Areas where they are particularly useful are material transfer areas, equipment areas, loading and unloading areas, or anywhere information might prevent contaminants from being released to storm water.

What to Consider

Signs and labels should be visible and easy to read. Useful signs and labels might provide the following information:

- Names of facility and regulatory personnel, including emergency phone numbers, to contact in case of an accidental discharge, spill, or other emergency
- Proper uses of equipment that could cause release of storm water contaminants
- Types of chemicals used in high-risk areas
- The direction of drainage lines/ditches and their destination (treatment or discharge)
- Information on a specific material
- Refer to OSHA standards for sizes and numbers of signs required for hazardous material labeling.

Hazardous chemicals might be labeled as follows:

- Danger
- Combustible
- Warning
- Caution
- Flammable
- Poisonous
- Caustic
- Corrosive
- Volatile
- Explosive

Periodic checks can ensure that signs are still in place and labels are properly attached. Signs and labels should be replaced and repaired as often as necessary.

| |
|--|
| Advantages of Signs and Labels |
| • Are inexpensive and easily used |
| Disadvantages of Signs and Labels |
| • Must be updated and maintained so they are legible |

Security

What Is It

Setting up a security system as part of your Plan could help prevent an accidental or intentional release of materials to storm water runoff as a result of vandalism, theft, sabotage, or other improper uses of facility property. If your facility already has a security system, consider improving it by training security personnel about the specifics of the Storm Water Pollution Prevention Plan. Routine patrol, lighting, and access control are discussed below as possible measures to include in your facility's security system.

When and Where to Use It

Routine patrol, lighting, and access control are measures that can be used at any facility.

What to Consider

Security information could be included in the existing training required by the Plan to instruct personnel about where and how to patrol areas within the facility. Instruction might also include what to look for in problem areas and how to respond to problems. During routine patrol, security personnel can actively search the facility site for indications of spills, leaks, or other discharges; respond to any disturbance resulting from intruders or inappropriate facility operations; and generally work as a safeguard to prevent unexpected events. Routine patrols could be an effective part of the Storm Water Pollution Prevention Plan, especially for large facilities with established security measures. To make this practice effective, security personnel can help develop the Storm Water Pollution Prevention Plan, possibly with one person acting as a member of the pollution prevention committee.

Sufficient lighting throughout the facility during daytime and night hours will make it easier to get to equipment during checks and will make it easy to detect spills and leaks that might otherwise be hidden. Routine patrols are also easier with proper lighting.

Controlling access to the industrial site is an important part of plant security and of activity and traffic control. Signs, fencing, guard houses, dog patrols, and visitor clearance requirements are often used to control site access.

- Signs are the simplest, most inexpensive method of access control, but they are limited in their actual control since they provide no physical barriers and require that people obey them voluntarily.
- Fencing provides a physical barrier to the facility site and an added means of security.
- Guard houses used with visitor rules can help to ensure that only authorized personnel enter the facility site and can limit vehicular traffic as well.
- Traffic signs are also useful at facility sites. Restricting vehicles to paved roads and providing direction and warning signs can help prevent accidents. Where restricting vehicles to certain pathways is not possible, it is important to ensure that all above-ground valves and pipelines are well marked.

| Advantages of Security |
|--|
| <ul style="list-style-type: none">• Provides a preventive safeguard to operational malfunctions or other facility disturbances (routine patrols)• Allows easier detection of vandals or thieves (lighting)• Allows easier detection of spills, leaks, or other releases (lighting)• Prevents spills by providing good visibility (lighting)• Prevents unauthorized access to facility (access control) |
| Disadvantages of Security |
| <ul style="list-style-type: none">• May not be feasible for smaller facilities• May be costly (e.g., installation of lighting systems)• May increase energy costs as a result of additional lighting• May not be feasible to have extensive access controls at smaller facilities |

Area Control Procedures

What Are They

The activities conducted at an industrial site often result in the materials being deposited on clothes and footwear and the being carried throughout the facility site. As a result, these materials may find their way into the storm water runoff.

Area control procedures involve practicing good housekeeping measures such as maintaining indoor or covered material storage and industrial processing areas. If the area is kept clean, the risk of accumulating materials on footwear and clothing is reduced. In turn, the chance of left over pollutants making contact with storm water and polluting surface water is minimized.

When and Where to Use Them

Area control measures can be used at any facility where materials may be tracked into areas where they can come in contact with storm water runoff. Areas can include material handling areas, storage areas, or process areas.

What to Consider

Materials storage areas and industrial processing areas should be checked regularly to ensure that good housekeeping measures are being implemented. Cover-garments, foot mats, and other devices used to collect residual material near the area should be cleaned regularly.

Other effective practices include the following:

- Brushing off clothing before leaving the area
- Stomping feet to remove material before leaving the area
- Using floor mats at area exits
- Using coveralls, smocks, and other overgarments in areas where exposure to material is of greatest concern (employees should remove the overgarments before leaving the area)
- Posting signs to remind employees about these practices.

Advantages of Area Control Procedures

- Are easy to implement
- Result in a cleaner facility and improved work environment

Disadvantage of Area Control Procedures

- May be seen as tedious by employees and therefore may not be followed

Vehicle Washing

What Is It

Materials that accumulate on vehicles and then scatter across industrial sites represent an important source of storm water contamination. Vehicle washing removes materials such as site-specific dust and spilled materials that have accumulated on the vehicle. If not removed, residual material will be spread by gravity, wind, snow, or rainfall as the vehicles move across the facility site and off the site.

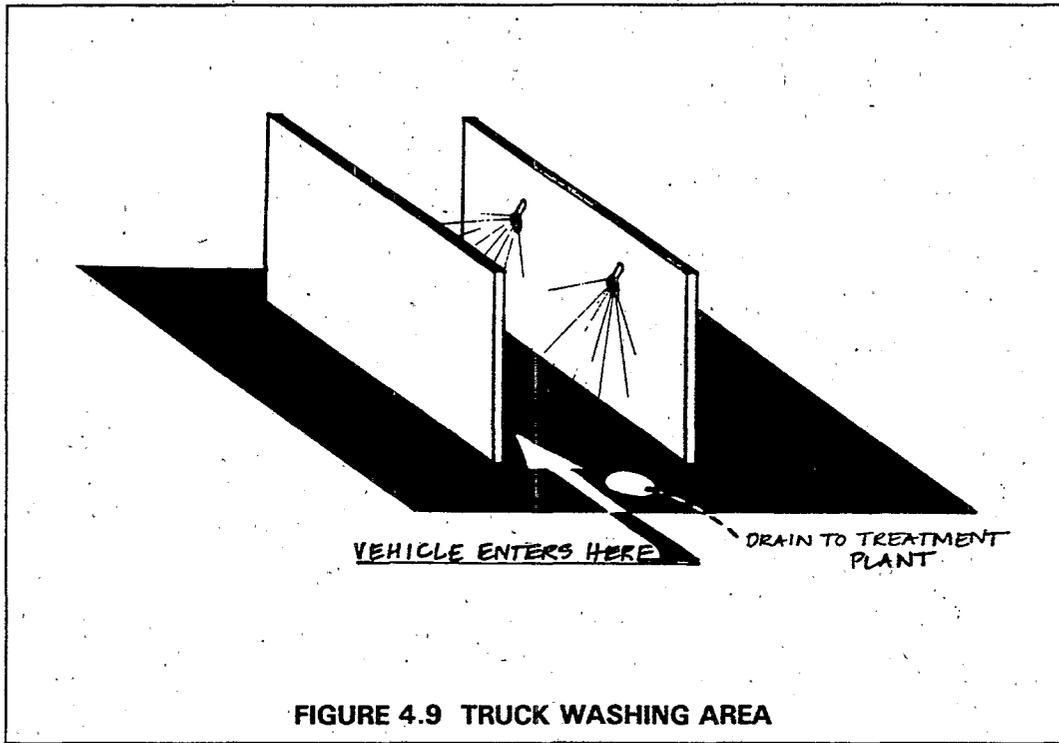


FIGURE 4.9 TRUCK WASHING AREA

When and Where to Use It

This practice is appropriate for any facility where vehicles come into contact with raw materials on a site. If possible, the vehicle washing area should be built near the location where the most vehicle activity occurs. Wastewater from vehicle washing should be directed away from process materials to prevent contact. Those areas include material transfer areas, loading and unloading areas, or areas located just before the site exit.

What to Consider

When considering the method of vehicle washing, the facility should consider using a high-pressure water spray with no detergent additives. In general, water will adequately remove contaminants from the vehicle. If detergents are used, they may cause other environmental impacts. Phosphate- or organic-containing compounds should be avoided.

If this practice is considered, truck wash waters will result in a non-storm water discharge, thus requiring an application for an NPDES permit to cover the discharge.

Blowers or vacuums should be considered where the materials are dry and easily removed by air.

| Advantages of Vehicle Washing |
|---|
| <ul style="list-style-type: none">• Prevents dispersion of materials across the facility site• Is necessary only where methods for transferring contained materials and minimizing exposure have not been successfully adopted and implemented |
| Disadvantages of Vehicle Washing |
| <ul style="list-style-type: none">• May be costly to construct a truck washing facility |

4.5 SEDIMENT AND EROSION PREVENTION PRACTICES

Any site where soils are exposed to water, wind or ice can have soil erosion and sedimentation problems. Erosion is a natural process in which soil and rock material is loosened and removed. Sedimentation occurs when soil particles are suspended in surface runoff or wind and are deposited in streams and other water bodies.

Human activities can accelerate erosion by removing vegetation, compacting or disturbing the soil, changing natural drainage patterns, and by covering the ground with impermeable surfaces (pavement, concrete, buildings). When the land surface is developed or "hardened" in this manner, storm water and snowmelt can not seep into or "infiltrate" the ground. This results in larger amounts of water moving more quickly across a site which can carry more sediment and other pollutants to streams and rivers.

EPA's General Permit requires that all industries identify in their Storm Water Pollution Prevention Plans areas that may have a high potential for soil erosion. This includes areas with such heavy activity that plants cannot grow, soil stockpiles, stream banks, steep slopes, construction areas, demolition areas, and any area where the soil is disturbed, denuded (stripped of plants), and subject to wind and water erosion. EPA further requires that you take steps to limit this erosion.

There are seven ways to limit and control sediment and erosion on your site:

- Leave as much vegetation (plants) onsite as possible.
- Minimize the time that soil is exposed.
- Prevent runoff from flowing across disturbed areas (divert the flow to vegetated areas).
- Stabilizing the disturbed soils as soon as possible.
- Slow down the runoff flowing across the site.
- Provide drainage ways for the increased runoff (use grassy swales rather than concrete drains).
- Remove sediment from storm water runoff before it leaves the site.

Using these measures to control erosion and sedimentation is an important part of storm water management. Selecting the best set of sediment and erosion prevention measures for your industry depends upon the nature of the activities on your site (i.e., how much construction or land disturbance there is) and other site-specific conditions (soil type, topography, climate, and season). Section 4.5.1 discusses some temporary and permanent ways to stabilize your site. Section 4.5.2 describes more structural ways to control sediment and erosion:

In some arid regions, growing vegetation to prevent erosion may be difficult. The local Soil Conservation Service Office or County Extension Office can provide information on any special measures necessary to promote the establishment of vegetation.

4.5.1 Vegetative Practices

Preserving existing vegetation or revegetating disturbed soil as soon as possible after construction is the most effective way to control erosion. A vegetation cover reduces erosion potential in four ways: (1) by shielding the soil surface from direct erosive impact of raindrops; (2) by improving

the soil's water storage porosity and capacity so more water can infiltrate into the ground; (3) by slowing the runoff and allowing the sediment to drop out or deposit; and (4) by physically holding the soil in place with plant roots.

Vegetative cover can be grass, trees, shrubs, bark, mulch, or straw. Grasses are the most common type of cover used for revegetation because they grow quickly, providing erosion protection within days. Other soil stabilization practices such as straw or mulch may be used during non-growing seasons to prevent erosion. Newly planted shrubs and trees establish root systems more slowly, so keeping existing ones is a more effective practice.

Vegetative and other site stabilization practices can be either temporary or permanent controls. Temporary controls provide a cover for exposed or disturbed areas for short periods of time or until permanent erosion controls are put in place. Permanent vegetative practices are used when activities that disturb the soil are completed or when erosion is occurring on a site that is otherwise stabilized. The remainder of this section describes the common vegetative practices listed below:

- Preservation of Natural Vegetation
- Buffer Zones
- Stream Bank Stabilization
- Mulching, Matting, and Netting
- Temporary Seeding
- Permanent Seeding and Planting
- Sodding
- Chemical Stabilization.

Preservation of Natural Vegetation

What Is It

The preservation of natural vegetation (existing trees, vines, brushes, and grasses) provides natural buffer zones. By preserving stabilized areas, it minimizes erosion potential, protects water quality, and provides aesthetic benefits. This practice is used as a permanent control measure.

When and Where to Use It

This technique is applicable to all types of sites. Areas where preserving vegetation can be particularly beneficial are floodplains, wetlands, stream banks, steep slopes, and other areas where erosion controls would be difficult to establish, install, or maintain.

What to Consider

Preservation of vegetation on a site should be planned before any site disturbance begins. Preservation requires good site management to minimize the impact of construction activities on existing vegetation. Clearly mark the trees to be preserved and protect them from ground disturbances around the base of the tree. Proper maintenance is important to ensure healthy vegetation that can control erosion. Different species, soil types, and climatic conditions will require different maintenance activities such as mowing, fertilizing, liming, irrigation, pruning, and weed and pest control. Some State/local regulations require natural vegetation to be preserved in sensitive areas; consult the appropriate State/local agencies for more information on their regulations. Maintenance should be performed regularly, especially during construction.

Advantages of Preservation of Natural Vegetation

- Can handle higher quantities of storm water runoff than newly seeded areas
- Does not require time to establish (i.e., effective immediately)
- Increases the filtering capacity because the vegetation and root structure are usually denser in preserved natural vegetation than in newly seeded or base areas
- Enhances aesthetics
- Provides areas for infiltration, reducing the quantity and velocity of storm water runoff
- Allows areas where wildlife can remain undisturbed
- Provides noise buffers and screens for onsite operations
- Usually requires less maintenance (e.g., irrigation, fertilizer) than planting new vegetation

Disadvantages of Preservation of Natural Vegetation

- Requires planning to preserve and maintain the existing vegetation
- May not be cost effective with high land costs
- May constrict area available for construction activities

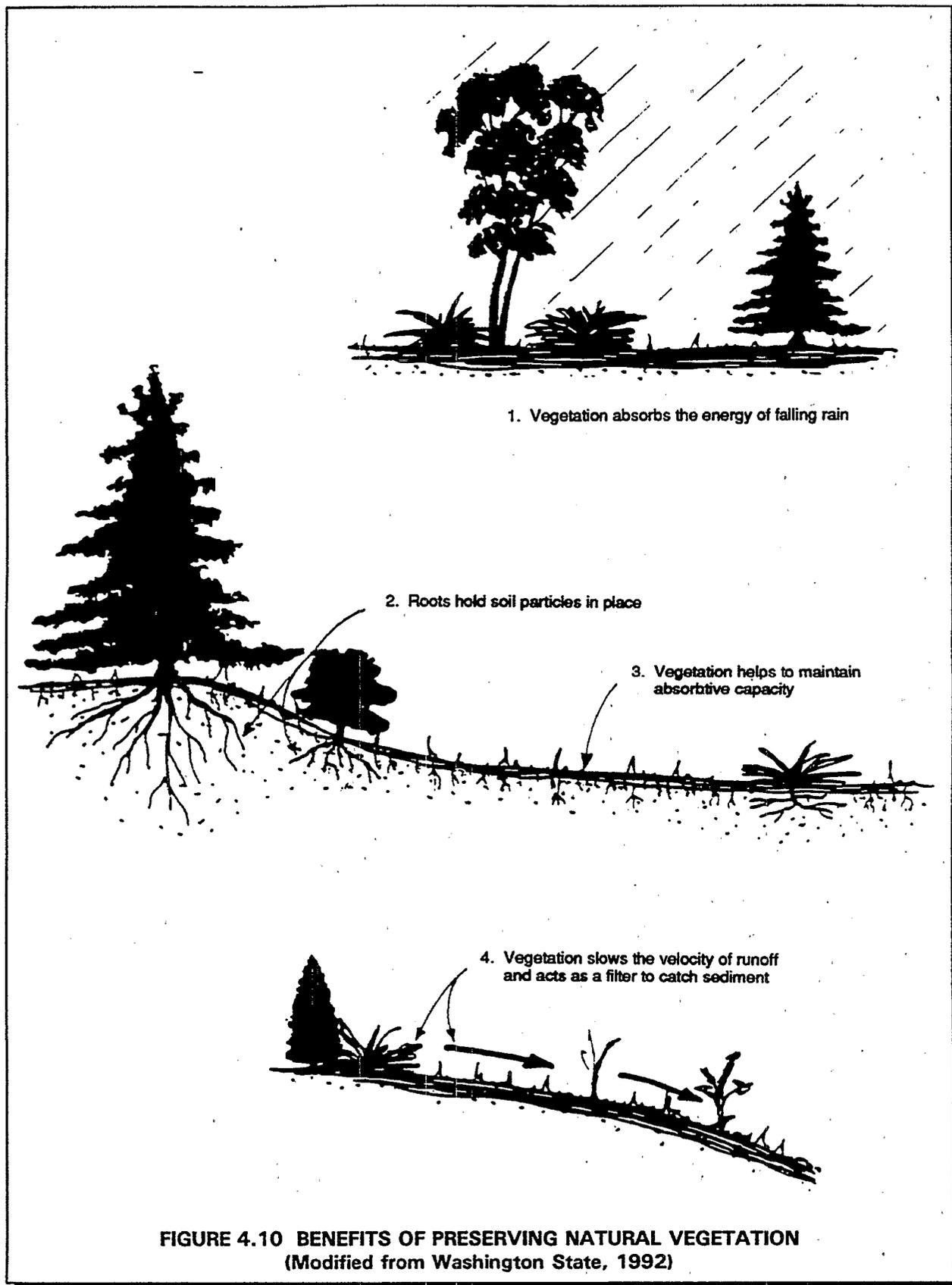


FIGURE 4.10 BENEFITS OF PRESERVING NATURAL VEGETATION
(Modified from Washington State, 1992)

Buffer Zones

What Are They

Buffer zones are vegetated strips of land used for temporary or permanent water quality benefits. Buffer zones are used to decrease the velocity of storm water runoff, which in turn helps to prevent soil erosion. Buffer zones are different from vegetated filter strips (see section on Vegetated Filter Strips) because buffer zone effectiveness is not measured by its ability to improve infiltration (allow water to go into the ground). The buffer zone can be an area of vegetation that is left undisturbed during construction, or it can be newly planted.

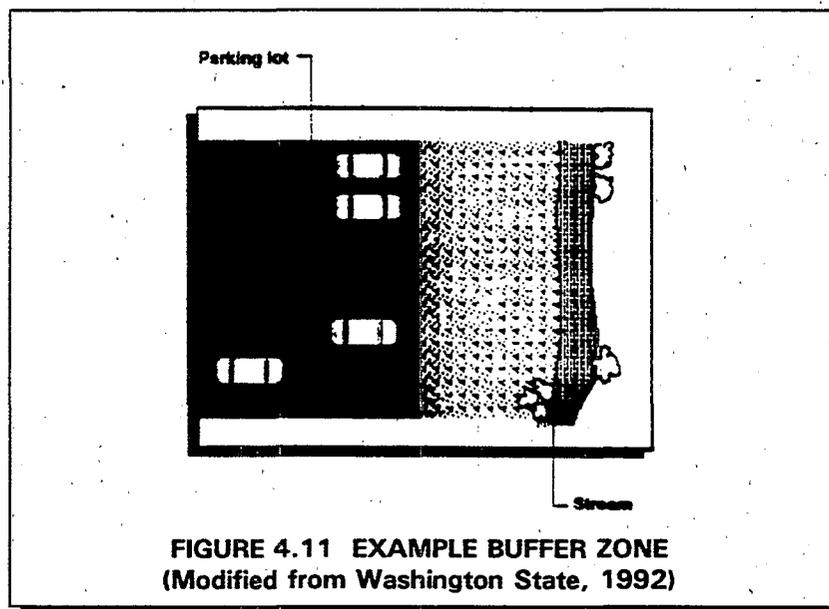


FIGURE 4.11 EXAMPLE BUFFER ZONE
(Modified from Washington State, 1992)

When and Where to Use Them

Buffer zones technique can be used at any site that can support vegetation. Buffer zones are particularly effective on floodplains, next to wetlands, along stream banks, and on steep, unstable slopes.

What to Consider

If buffer zones are preserved, existing vegetation, good planning, and site management are needed to protect against disturbances such as grade changes, excavation, damage from equipment, and other activities. Establishing new buffer strips requires the establishment of a good dense turf, trees, and shrubs (see Permanent Seeding and Planting). Careful maintenance is important to ensure healthy vegetation. The need for routine maintenance such as mowing, fertilizing, liming, irrigating, pruning, and weed and pest control will depend on the species of plants and trees involved, soil types, and climatic conditions. Maintaining planted areas may require debris removal and protection against unintended uses or traffic. Many State/local storm water program or zoning

agencies have regulations which define required or allowable buffer zones especially near sensitive areas such as wetlands. Contact the appropriate State/local agencies for their requirements.

| Advantages of Buffer Zones |
|--|
| <ul style="list-style-type: none">• Provide aesthetic as well as water quality benefits• Provide areas for infiltration, which reduces amount and speed of storm water runoff• Provide areas for wildlife habitat• Provide areas for recreation• Provide buffers and screens for onsite noise if trees or large bushes are used• Low maintenance requirements• Low cost when using existing vegetation |
| Disadvantages of Buffer Zones |
| <ul style="list-style-type: none">• May not be cost effective to use if the cost of land is high• Are not feasible if land is not available• Require plant growth before they are effective |

Stream Bank Stabilization

What Is It

Stream bank stabilization is used to prevent stream bank erosion from high velocities and quantities of storm water runoff. Typical methods include the following:

- **Riprap**—Large angular stones placed along the stream bank or lake
- **Gabion**—Rock-filled wire cages that are used to create a new stream bank
- **Reinforced Concrete**—Concrete bulkheads and retaining walls that replace natural stream banks and create a nonerosive surface
- **Log Cribbing**—Retaining walls built of logs to anchor the soils against erosive forces. Usually built on the outside of stream bends
- **Grid Pavers**—Precast or poured-in-place concrete units that are placed along stream banks to stabilize the stream bank and create open spaces where vegetation can be established
- **Asphalt**—Asphalt paving that is placed along the natural stream bank to create a nonerosive surface.

When and Where to Use It

Stream bank stabilization is used where vegetative stabilization practices are not practical and where the stream banks are subject to heavy erosion from increased flows or disturbance during construction. Stabilization should occur before any land development in the watershed area. Stabilization can also be retrofitted when erosion of a stream bank occurs.

What to Consider

Stream bank stabilization structures should be planned and designed by a professional engineer licensed in the State where the site is located. Applicable Federal, State, and local requirements should be followed, including Clean Water Act Section 404 regulations. An important design feature of stream bank stabilization methods is the foundation of the structure; the potential for the stream to erode the sides and bottom of the channel should be considered to make sure the stabilization measure will be supported properly. Structures can be designed to protect and improve natural wildlife habitats; for example, log structures and grid pavers can be designed to keep vegetation. Only pressure-treated wood should be used in log structures. Permanent structures should be designed to handle expected flood conditions. A well-designed layer of stone can be used in many ways and in many locations to control erosion and sedimentation. Riprap protects soil from erosion and is often used on steep slopes built with fill materials that are subject to harsh weather or seepage. Riprap can also be used for flow channel liners, inlet and outlet protection at culverts, stream bank protection, and protection of shore lines subject to wave action. It is used where water is turbulent and fast flowing and where soil may erode under the design flow conditions. It is used to expose the water to air as well as to reduce water energy. Riprap and gabion (wire mesh cages filled with rock) are usually placed over a filter blanket (i.e., a gravel layer or filter cloth). Riprap is either a uniform size or graded (different sizes) and is usually applied in an even layer throughout the stream. Reinforced concrete structures may require positive

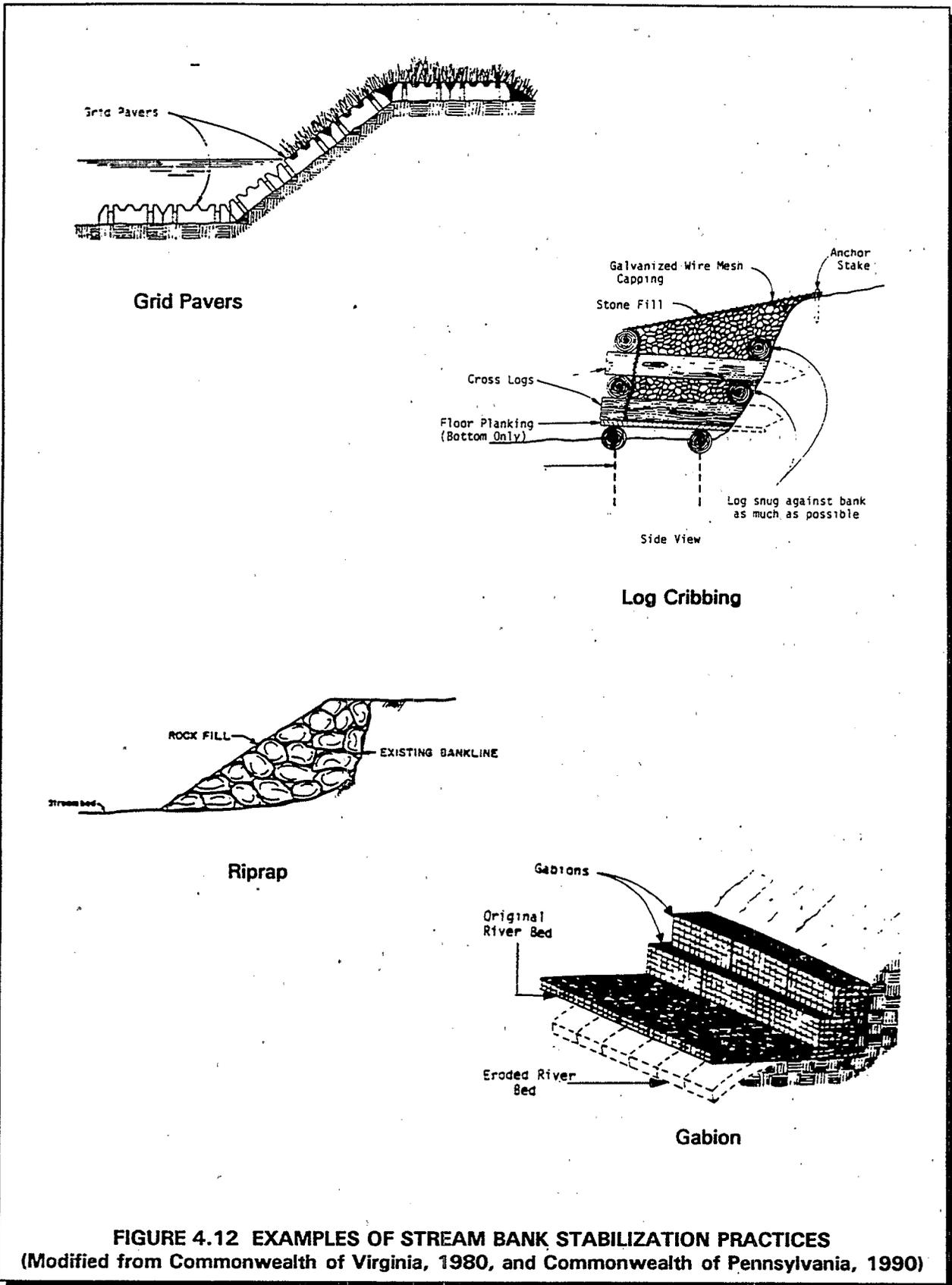


FIGURE 4.12 EXAMPLES OF STREAM BANK STABILIZATION PRACTICES
(Modified from Commonwealth of Virginia, 1980, and Commonwealth of Pennsylvania, 1990)

drainage behind the bulkhead or retaining wall to prevent erosion around the structure. Gabion and grid pavers should be installed according to manufacturers' recommendations.

Stream bank stabilization structures should be inspected regularly and after each large storm event. Structures should be maintained as installed. Structural damage should be repaired as soon as possible to prevent further damage or erosion to the stream bank.

Advantages of Stream Bank Stabilization

- Can provide control against erosive forces caused by the increase in storm water flows created during land development
- Usually will not require as much maintenance as vegetative erosion controls
- May provide wildlife habitats
- Forms a dense, flexible, self-healing cover that will adapt well to uneven surfaces (riprap)

Disadvantages of Stream Bank Stabilization

- Does not provide the water quality or aesthetic benefits that vegetative practices could
- Should be designed by qualified professional engineers, which may increase project costs
- May be expensive (materials costs)
- May require additional permits for structure
- May alter stream dynamics which cause changes in the channel downstream
- May cause negative impacts to wildlife habitats

Mulching, Matting, and Netting

What Are They

Mulching is a temporary soil stabilization or erosion control practice where materials such as grass, hay, woodchips, wood fibers, straw, or gravel are placed on the soil surface. In addition to stabilizing soils, mulching can reduce the speed of storm water runoff over an area. When used together with seeding or planting, mulching can aid in plant growth by holding the seeds, fertilizers, and topsoil in place, by preventing birds from eating seeds, helping to retain moisture, and by insulating against extreme temperatures. Mulch mattings are materials (jute or other wood fibers) that have been formed into sheets of mulch that are more stable than normal mulch. Netting is typically made from jute, other wood fiber, plastic, paper, or cotton and can be used to hold the mulching and matting to the ground. Netting can also be used alone to stabilize soils while the plants are growing; however, it does not retain moisture or temperature well. Mulch binders (either asphalt or synthetic) are sometimes used instead of netting to hold loose mulches together.

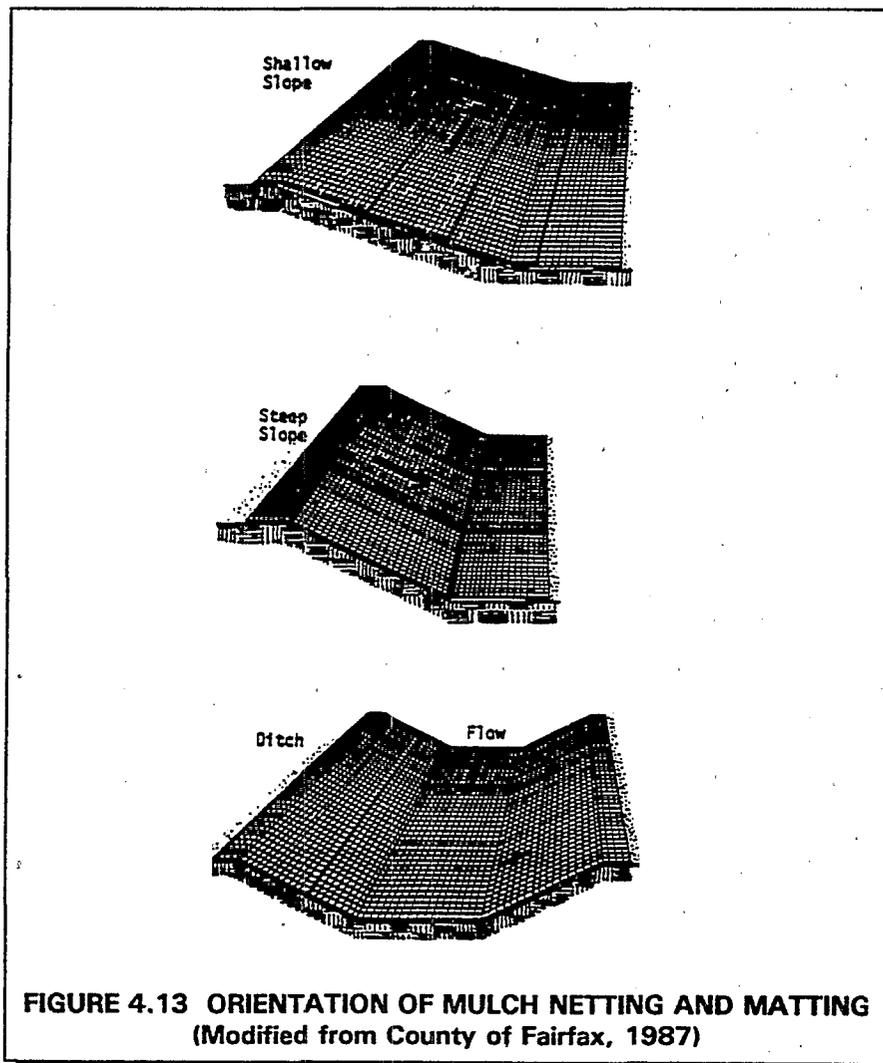


FIGURE 4.13 ORIENTATION OF MULCH NETTING AND MATTING
(Modified from County of Fairfax, 1987)

When and Where to Use Them

Mulching is often used alone in areas where temporary seeding cannot be used because of the season or climate. Mulching can provide immediate, effective, and inexpensive erosion control. On steep slopes and critical areas such as waterways, mulch matting is used with netting or anchoring to hold it in place.

Mulch seeded and planted areas where slopes are steeper than 2:1, where runoff is flowing across the area, or when seedlings need protection from bad weather.

What to Consider

Use of mulch may or may not require a binder, netting, or the tacking of mulch to the ground. Effective netting and matting require firm, continuous contact between the materials and the soil. If there is no contact, the material will not hold the soil and erosion will occur underneath the material. Final grading is not necessary before mulching. Mulched areas should be inspected often to find where mulched material has been loosened or removed. Such areas should be reseeded (if necessary) and the mulch cover replaced immediately. Mulch binders should be applied at rates recommended by the manufacturer or, if asphalt is used, at rates of approximately 480 gallons per acre (Arapahoe County, 1988).

Advantages of Mulching, Matting, and Netting

- Provide immediate protection to soils that are exposed and that are subject to heavy erosion
- Retain moisture, which may minimize the need for watering
- Require no removal because of natural deterioration of mulching and matting

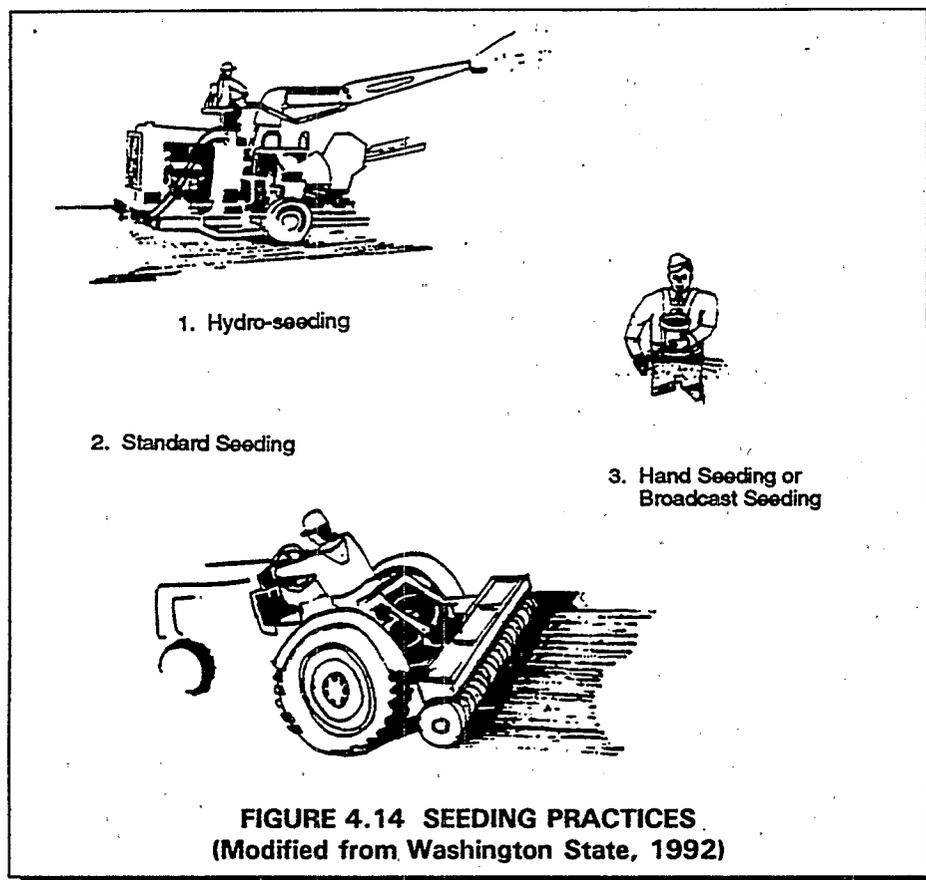
Disadvantages of Mulching, Matting, and Netting

- May delay germination of some seeds because cover reduces the soil surface temperature
- Netting should be removed after usefulness is finished, then landfilled or composted

Temporary Seeding

What Is It

Temporary seeding means growing a short-term vegetative cover (plants) on disturbed site areas that may be in danger of erosion. The purpose of temporary seeding is to reduce erosion and sedimentation by stabilizing disturbed areas that will not be stabilized for long periods of time or where permanent plant growth is not necessary or appropriate. This practice uses fast-growing grasses whose root systems hold down the soils so that they are less apt to be carried offsite by storm water runoff or wind. Temporary seeding also reduces the problems associated with mud and dust from bare soil surfaces during construction.



When and Where to Use It

Temporary seeding should be performed on areas which have been disturbed by construction and which are likely to be redisturbed, but not for several weeks or more. Typical areas might include denuded areas, soil stockpiles, dikes, dams, sides of sediment basins, and temporary roadbanks. Temporary seeding should take place as soon as practicable after the last land disturbing activity in an area. Check the requirements of your permit for the maximum amount of time allowed between the last disturbance of an area and temporary stabilization. Temporary seeding may not be an

effective practice in arid and semi-arid regions where the climate prevents fast plant growth, particularly during the dry seasons. In those areas, mulching or chemical stabilization may be better for the short-term (see sections on Mulching, Geotextiles, and Chemical Stabilization).

What to Consider

Proper seed bed preparation and the use of high-quality seed are needed to grow plants for effective erosion control. Soil that has been compacted by heavy traffic or machinery may need to be loosened. Successful growth usually requires that the soil be tilled before the seed is applied. Topsoiling is not necessary for temporary seeding; however, it may improve the chances of establishing temporary vegetation in an area. Seed bed preparation may also require applying fertilizer and/or lime to the soil to make conditions more suitable for plant growth. Proper fertilizer, seeding mixtures, and seeding rates vary depending on the location of the site, soil types, slopes, and season. Local suppliers, State and local regulatory agencies, and the USDA Soil Conservation Service will supply information on the best seed mixes and soil conditioning methods.

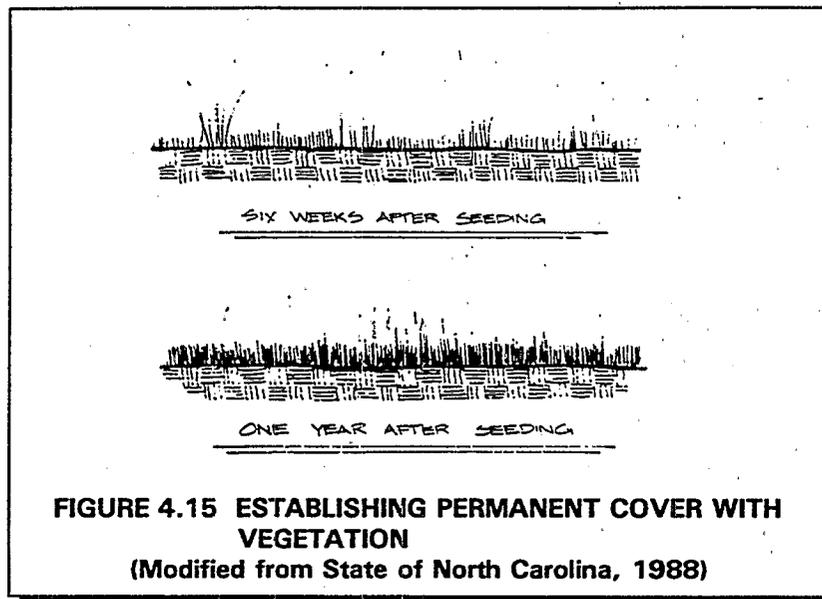
Seeded areas should be covered with mulch to provide protection from the weather. Seeding on slopes of 2:1 or more, in adverse soil conditions, during excessively hot or dry weather, or where heavy rain is expected should be followed by spreading mulch (see section on Mulching). Frequent inspections are necessary to check that conditions for growth are good. If the plants do not grow quickly or thick enough to prevent erosion, the area should be reseeded as soon as possible. Seeded areas should be kept adequately moist. If normal rainfall will not be enough, mulching, matting, and controlled watering should be done. If seeded areas are watered, watering rates should be watched so that over-irrigation (which can cause erosion itself) does not occur.

| Advantages of Temporary Seeding |
|--|
| <ul style="list-style-type: none"> • Is generally inexpensive and easy to do • Establishes plant cover fast when conditions are good • Stabilizes soils well, is aesthetic, and can provide sedimentation controls for other site areas • May help reduce costs of maintenance on other erosion controls (e.g., sediment basins may need to be cleaned out less often) |
| Disadvantages of Temporary Seeding |
| <ul style="list-style-type: none"> • Depends heavily on the season and rainfall rate for success • May require extensive fertilizing of plants grown on some soils, which can cause problems with local water quality • Requires protection from heavy use, once seeded • May produce vegetation that requires irrigation and maintenance |

Permanent Seeding and Planting

What Is It

Permanent seeding of grass and planting trees and brush provides stabilization to the soil by holding soil particles in place. Vegetation reduces sediments and runoff to downstream areas by slowing the velocity of runoff and permitting greater infiltration of the runoff. Vegetation also filters sediments, helps the soil absorb water, improves wildlife habitats, and enhances the aesthetics of a site.



When and Where to Use It

Permanent seeding and planting is appropriate for any graded or cleared area where long-lived plant cover is desired. Some areas where permanent seeding is especially important are filter strips, buffer areas, vegetated swales, steep slopes, and stream banks. This practice is effective on areas where soils are unstable because of their texture, structure, a high water table, high winds, or high slope. When seeding in northern areas during fall or winter, cover the area with mulch to provide a protective barrier against cold weather (see Mulching). Seeding should also be mulched if the seeded area slopes 4:1 or more, if soil is sandy or clayey, or if weather is excessively hot or dry. Plant when conditions are most favorable for growth. When possible, use low-maintenance local plant species. Install all other erosion control practices such as dikes, basins, and surface runoff control measures before planting.

What to Consider

For this practice to work, it is important to select appropriate vegetation, prepare a good seedbed, properly time planting, and water and fertilize. Planting local plants during their regular growing

season will increase the chances for success and may lessen the need for watering. Check seeded areas frequently for proper watering and growth conditions.

Topsoil should be used on areas where topsoils have been removed, where the soils are dense or impermeable, or where mulching and fertilizers alone cannot improve soil quality. Topsoiling should be coordinated with the seeding and planting practices and should not be planned while the ground is frozen or too wet. Topsoil layers should be at least 2 inches deep (or similar to the existing topsoil depth).

To minimize erosion and sedimentation, remove as little existing topsoil as possible. All site controls should be in place before the topsoil is removed. If topsoils are brought in from another site, it is important that its texture is compatible with the subsoils onsite; for example, sandy topsoils are not compatible with clay subsoils.

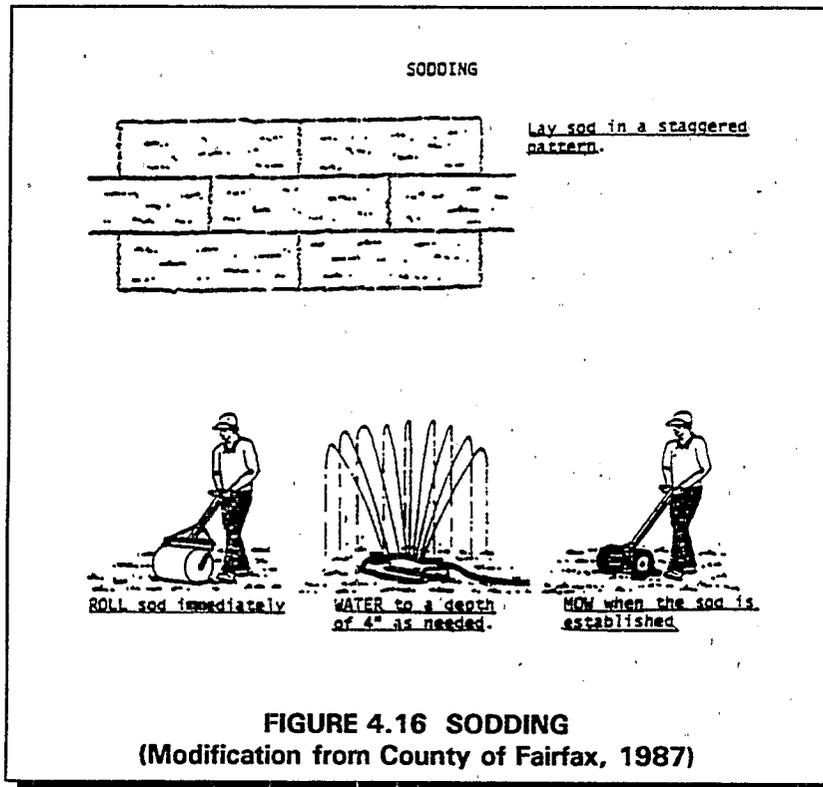
Stockpiling of topsoils onsite requires good planning so soils will not obstruct other operations. If soil is to be stockpiled, consider using temporary seeding, mulching, or silt fencing to prevent or control erosion. Inspect the stockpiles frequently for erosion. After topsoil has been spread, inspect it regularly, and reseed or replace areas that have eroded.

| Advantages of Permanent Seeding and Planting |
|--|
| <ul style="list-style-type: none">• Improves the aesthetics of a site• Provides excellent stabilization• Provides filtering of sediments• Provides wildlife habitat• Is relatively inexpensive |
| Disadvantages of Permanent Seeding and Planting |
| <ul style="list-style-type: none">• May require irrigation to establish vegetation• Depends initially on climate and weather for success |

Sodding

What Is It

Sodding stabilizes an area by establishing permanent vegetation, providing erosion and sedimentation controls, and providing areas where storm water can infiltrate the ground.



When and Where to Use It

Sodding is appropriate for any graded or cleared area that might erode and where a permanent, long-lived plant cover is needed immediately. Examples of where sodding can be used are buffer zones, stream banks, dikes, swales, slopes, outlets, level spreaders, and filter strips.

What to Consider

The soil surface should be fine-graded before laying down the sod. Topsoil may be needed in areas where the soil textures are inadequate (see topsoil discussion in section on Permanent Seeding and Planting). Lime and fertilizers should be added to the soil to promote good growth conditions. Sodding can be applied in alternating strips or other patterns, or alternate areas can be seeded to reduce expense. Sod should not be planted during very hot or wet weather. Sod should not be placed on slopes that are greater than 3:1 if they are to be mowed. If placed on steep slopes, sod should be laid with staggered joints and/or be pegged. In areas such as steep slopes or next to

running waterways, chicken wire, jute, or other netting can be placed over the sod for extra protection against lifting (see Mulching, Matting, and Netting). Rolled or compact immediately after installation to ensure firm contact with the underlying topsoil. Inspect the sod frequently after it is first installed, especially after large storm events, until it is established as permanent cover. Remove and replace dead sod. Watering may be necessary after planting and during periods of intense heat and/or lack of rain.

| Advantages of Sodding |
|--|
| <ul style="list-style-type: none">• Can provide immediate vegetative cover and erosion control• Provides more stabilizing protection than initial seeding through dense cover formed by sod• Produces lower weed growth than seeded vegetation• Can be used for site activities within a shorter time than can seeded vegetation• Can be placed at any time of the year as long as moisture conditions in the soil are favorable, except when the ground is frozen |
| Disadvantages of Sodding |
| <ul style="list-style-type: none">• Purchase and installation costs are higher than for seeding• May require continued irrigation if the sod is placed during dry seasons or on sandy soils |

Chemical Stabilization

What Is It

Chemical stabilization practices, often referred to as a chemical mulch, soil binder, or soil palliative, are temporary erosion control practices. Materials made of vinyl, asphalt, or rubber are sprayed onto the surface of the soil to hold the soil in place and protect against erosion from storm water runoff and wind. Many of the products used for chemical stabilization are human-made, and many different products are on the market.

When and Where to Use It

Chemical stabilization can be used as an alternative in areas where temporary seeding practices cannot be used because of the season or climate. It can provide immediate, effective, and inexpensive erosion control anywhere erosion is occurring on a site.

What to Consider

The application rates and procedures recommended by the manufacturer of a chemical stabilization product should be followed as closely as possible to prevent the products from forming ponds and from creating large areas where moisture cannot get through.

| Advantages of Chemical Stabilization |
|---|
| <ul style="list-style-type: none">• Is easily applied to the surface of the soil• Is effective in stabilizing areas where plants will not grow• Provides immediate protection to soils that are in danger of erosion |
| Disadvantages of Chemical Stabilization |
| <ul style="list-style-type: none">• Can create impervious surfaces (where water cannot get through), which may in turn increase the amount and speed of storm water runoff• May cause harmful effects on water quality if not used correctly• Is usually more expensive than vegetative cover |

4.5.2 Structural Erosion Prevention and Sediment Control Practices

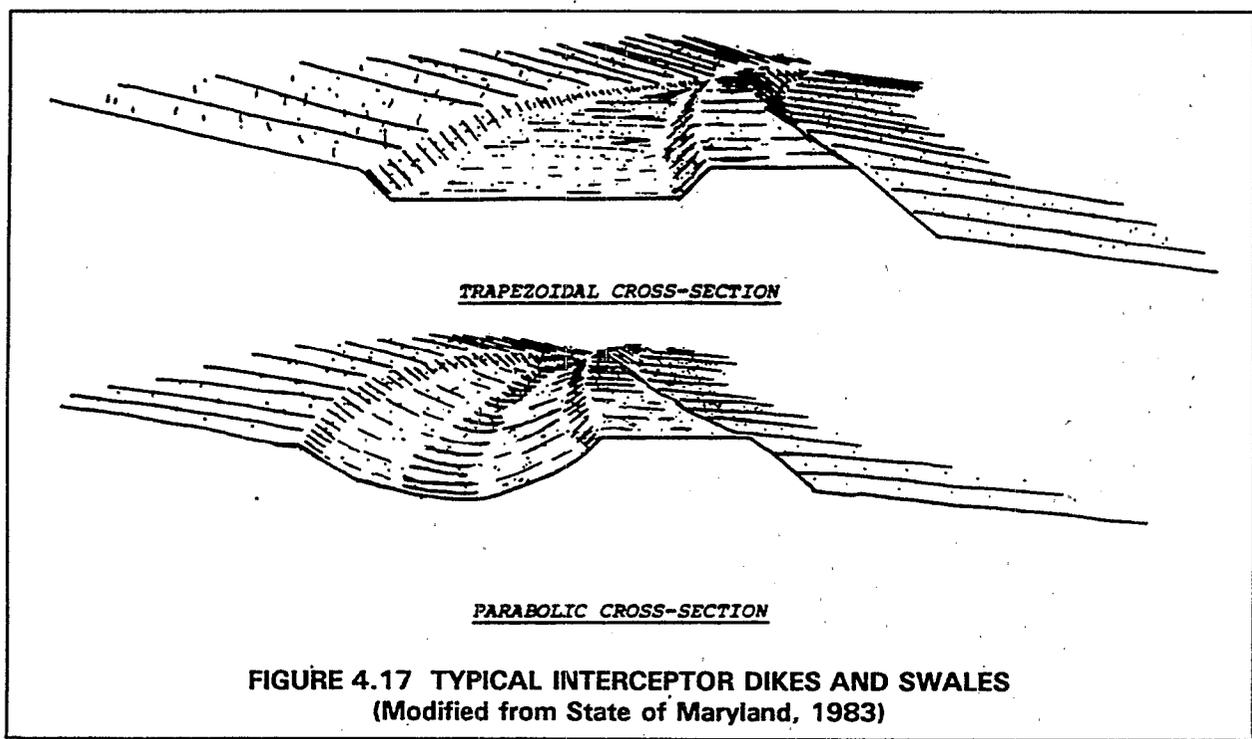
Structural practices used in sediment and erosion control divert storm water flows away from exposed areas, convey runoff, prevent sediments from moving offsite, and can also reduce the erosive forces of runoff waters. The controls can either be used as permanent or temporary measures. Practices discussed include the following:

- Interceptor Dikes and Swales
- Pipe Slope Drains
- Subsurface Drains
- Filter Fence
- Straw Bale Barrier
- Brush Barrier
- Gravel or Stone Filter Berm
- Storm Drain Inlet Protection
- Sediment Trap
- Temporary Sediment Basin
- Outlet Protection
- Check Dams
- Surface Roughening
- Gradient Terraces.

Interceptor Dikes and Swales

What Are They

Interceptor dikes (ridges of compacted soil) and swales (excavated depressions) are used to keep upslope runoff from crossing areas where there is a high risk of erosion. They reduce the amount and speed of flow and then guide it to a stabilized outfall (point of discharge) (see section on Outlet Protection) or sediment trapping area (see sections on Level Spreaders, Vegetated Filter Strips, Sediment Traps, and Temporary Sediment Basins). Interceptor dikes and swales divert runoff using a combination of earth dike and vegetated swale. Runoff is channeled away from locations where there is a high risk of erosion by placing a diversion dike or swale at the top of a sloping disturbed area. Dikes and swales also collect overland flow, changing it into concentrated flows (i.e., flows that are combined). Interceptor dikes and swales can be either temporary or permanent storm water control structures.



When and Where to Use Them

Interceptor dikes and swales are generally built around the perimeter of a construction site before any major soil disturbing activity takes place. Temporary dikes or swales may also be used to protect existing buildings; areas, such as stockpiles; or other small areas that have not yet been fully stabilized. When constructed along the upslope perimeter of a disturbed or high-risk area (though not necessarily all the way around it), dikes or swales prevent runoff from uphill areas from crossing the unprotected slope. Temporary dikes or swales constructed on the down slope side of the disturbed or high-risk area will prevent runoff that contains sediment from leaving the site

before sediment is removed. For short slopes, a dike or swale at the top of the slope reduces the amount of runoff reaching the disturbed area. For longer slopes, several dikes or swales are placed across the slope at intervals. This practice reduces the amount of runoff that accumulates on the face of the slope and carries the runoff safely down the slope. In all cases, runoff is guided to a sediment trapping area or a stabilized outfall before release.

What to Consider

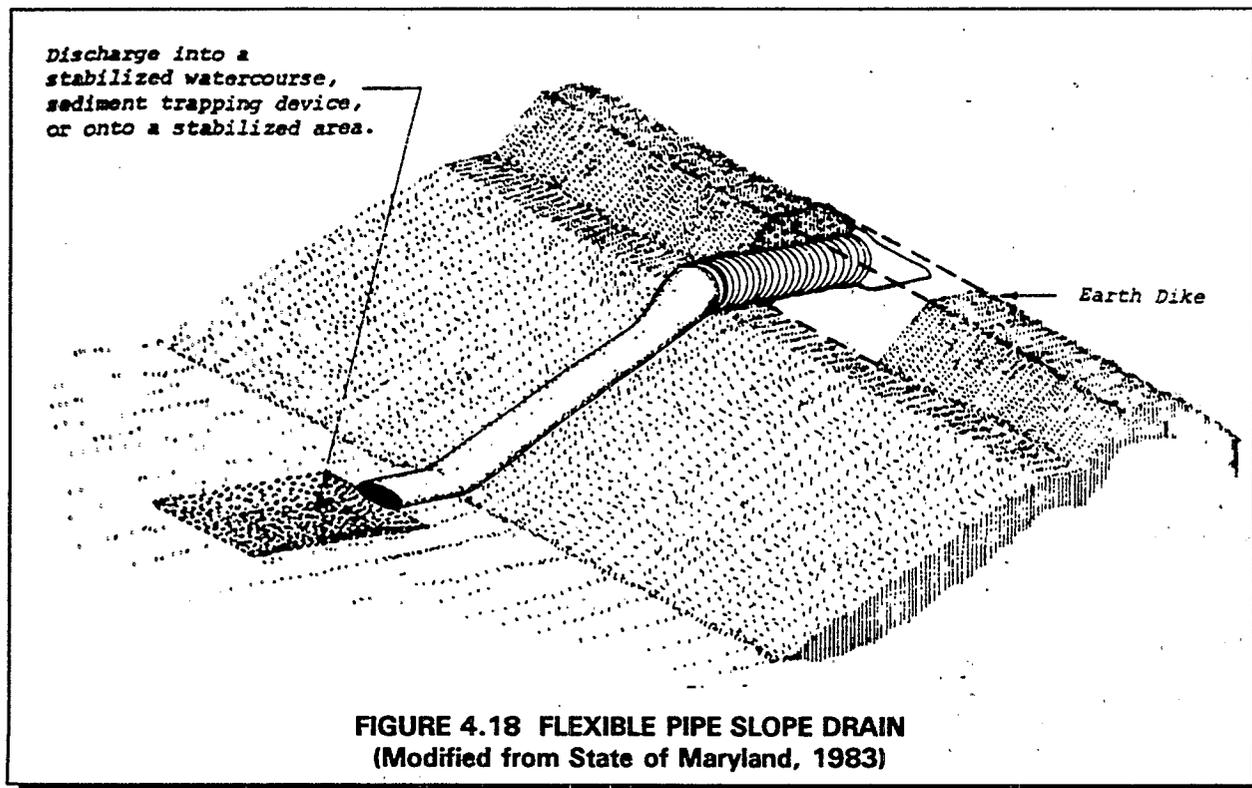
Temporary dikes and swales are used in areas of overland flow; if they remain in place longer than 15 days, they should be stabilized. Runoff channeled by a dike or swale should be directed to an adequate sediment trapping area or stabilized outfall. Care should be taken to provide enough slope for drainage but not too much slope to cause erosion due to high runoff flow speed. Temporary interceptor dikes and swales may remain in place as long as 12 to 18 months (with proper stabilization) or be rebuilt at the end of each day's activities. Dikes or swales should remain in place until the area they were built to protect is permanently stabilized. Interceptor dikes and swales can be permanent controls. However, permanent controls: should be designed to handle runoff after construction is complete; should be permanently stabilized; and should be inspected and maintained on a regular basis. Temporary and permanent control measures should be inspected once each week on a regular schedule and after every storm. Repairs necessary to the dike and flow channel should be made promptly.

| Advantages of Interceptor Dikes and Swales |
|---|
| <ul style="list-style-type: none"> • Are simple and effective for channeling runoff away from areas subject to erosion • Can handle flows from large drainage areas • Are inexpensive because they use materials and equipment normally found onsite |
| Disadvantages of Interceptor Dikes and Swales |
| <ul style="list-style-type: none"> • If constructed improperly, can cause erosion and sediment transport since flows are concentrated • May cause problems to vegetation growth if water flow is too fast • Require additional maintenance, inspections, and repairs |

Pipe Slope Drains

What Are They

Pipe slope drains reduce the risk of erosion by discharging runoff to stabilized areas. Made of flexible or rigid pipe, they carry concentrated runoff from the top to the bottom of a slope that has already been damaged by erosion or is at high risk for erosion. They are also used to drain saturated slopes that have the potential for soil slides. Pipe slope drains can be either temporary or permanent depending on the method of installation and material used.



When and Where to Use Them

Pipe slope drains are used whenever it is necessary to convey water down a slope without causing erosion. They are especially effective before a slope has been stabilized or before permanent drainage structures are ready for use. Pipe slope drains may be used with other devices, including diversion dikes or swales, sediment traps, and level spreaders (used to spread out storm water runoff uniformly over the surface of the ground). Temporary pipe slope drains, usually flexible tubing or conduit, may be installed prior to the construction of permanent drainage structures. Permanent slope drains may be placed on or beneath the ground surface; pipes, sectional downdrains, paved chutes, or clay tiles may be used.

Paved chutes may be covered with a surface of concrete or other impenetrable material. Subsurface drains can be constructed of concrete, PVC, clay tile, corrugated metal, or other permanent material.—

What to Consider

The drain design should be able to handle the volume of flow. The effective life span of a temporary pipe slope drain is up to 30 days after permanent stabilization has been achieved. The maximum recommended drainage area for pipe slope drains is 10 acres (Washington State, 1992).

The inlets and outlets of a pipe slope drain should be stabilized. This means that a flared end section should be used at the entrance of the pipe. The soil around the pipe entrance should be fully compacted. The soil at the discharge end of the pipe should be stabilized with riprap (a combination of large stones, cobbles, and boulders). The riprap should be placed along the bottom of a swale which leads to a sediment trapping structure or another stabilized area.

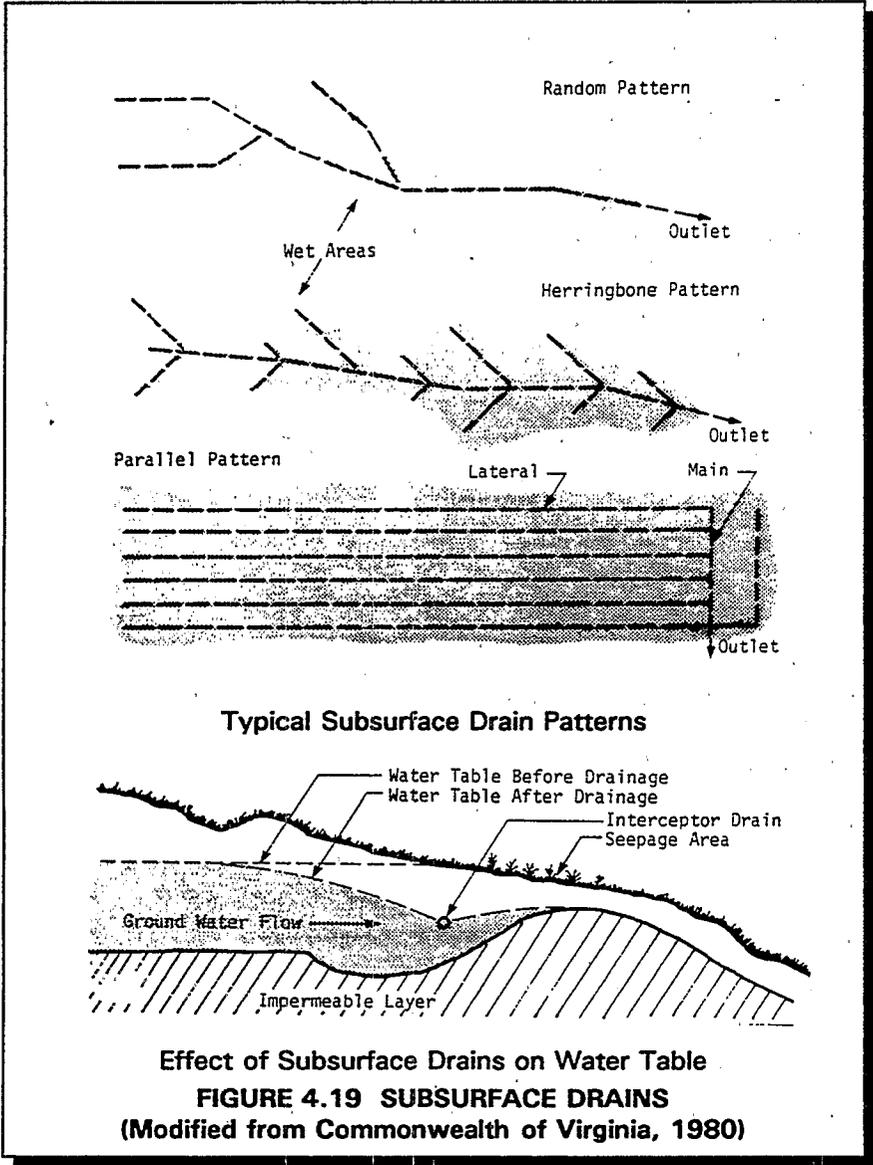
Pipe slope drains should be inspected on a regular schedule and after any major storm. Be sure that the inlet from the pipe is properly installed to prevent bypassing the inlet and undercutting the structure. If necessary, install a headwall, riprap, or sandbags around the inlet. Check the outlet point for erosion and check the pipe for breaks or clogs. Install outlet protection if needed and promptly clear breaks and clogs.

| Advantages of Pipe Slope Drains |
|--|
| <ul style="list-style-type: none">• Can reduce or eliminate erosion by transporting runoff down steep slopes or by draining saturated soils• Are easy to install and require little maintenance |
| Disadvantages of Pipe Slope Drains |
| <ul style="list-style-type: none">• Require that the area disturbed by the installation of the drain should be stabilized or it, too, will be subject to erosion• May clog during a large storm |

Subsurface Drains

What Are They

A subsurface drain is a perforated pipe or conduit placed beneath the surface of the ground at a designed depth and grade. It is used to drain an area by lowering the water table. A high water table can saturate soils and prevent the growth of certain types of vegetation. Saturated soils on slopes will sometimes "slip" down the hill. Installing subsurface drains can help prevent these problems.



When and Where to Use Them

There are two types of subsurface drains: relief drains and interceptor drains. Relief drains are used to dewater an area where the water table is high. They may be placed in a gridiron, herringbone, or random pattern. Interceptor drains are used to remove water where sloping soils are excessively wet or subject to slippage. They are usually placed as single pipes instead of in patterns. Generally, subsurface drains are suitable only in areas where the soil is deep enough for proper installation. They are not recommended where they pass under heavy vehicle crossings.

What to Consider

Drains should be placed so that tree roots will not interfere with drainage pipes. The drain design should be adequate to handle the volume of flow. Areas disturbed by the installation of a drain should be stabilized or they, too, will be subject to erosion. The soil layer must be deep enough to allow proper installation.

Backfill immediately after the pipe is placed. Material used for backfill should be open granular soil that is highly permeable. The outlet should be stabilized and should direct sediment-laden storm water runoff to a sediment trapping structure or another stabilized area.

Inspect subsurface drains on a regular schedule and check for evidence of pipe breaks or clogging by sediment, debris, or tree roots. Remove blockage immediately, replace any broken sections, and restabilize the surface. If the blockage is from tree roots, it may be necessary to relocate the drain. Check inlets and outlets for sediment or debris. Remove and dispose of these materials properly.

| Advantages of Subsurface Drains |
|---|
| <ul style="list-style-type: none">• Provide an effective method for stabilizing wet sloping soils• Are an effective way to lower the water table |
| Disadvantages of Subsurface Drains |
| <ul style="list-style-type: none">• May be pierced and clogged by tree roots• Should not be installed under heavy vehicle crossings• Cost more than surface drains because of the expenses of excavation for installation |

Filter Fence

What Is It

A silt fence, also called a "filter fence," is a temporary measure for sedimentation control. It usually consists of posts with filter fabric stretched across the posts and sometimes with a wire support fence. The lower edge of the fence is vertically trenched and covered by backfill. A silt fence is used in small drainage areas to detain sediment. These fences are most effective where there is overland flow (runoff that flows over the surface of the ground as a thin, even layer) or in minor swales or drainageways. They prevent sediment from entering receiving waters. Silt fences are also used to catch wind blown sand and to create an anchor for sand dune creation. Aside from the traditional wooden post and filter fabric method, there are several variations of silt fence installation including silt fence which can be purchased with pockets pre-sewn to accept use of steel fence posts.

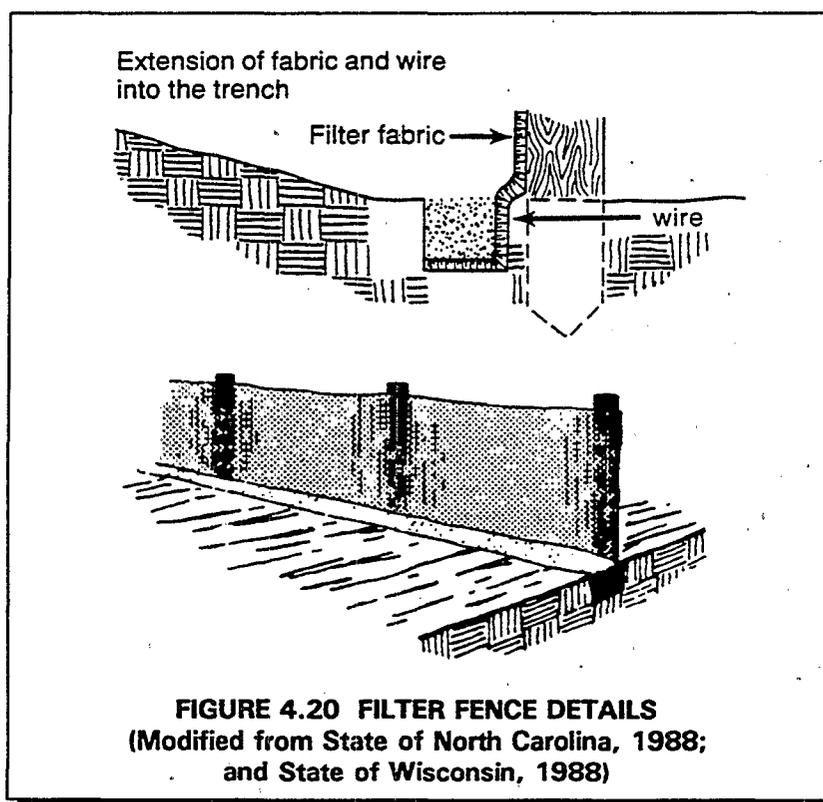


FIGURE 4.20 FILTER FENCE DETAILS
(Modified from State of North Carolina, 1988;
and State of Wisconsin, 1988)

When and Where to Use It

A silt fence should be installed prior to major soil disturbance in the drainage area. Such a structure is only appropriate for drainage areas of 1 acre or less with velocities of 0.5 cfs or less (Washington State, 1992). The fence should be placed across the bottom of a slope or minor drainageway along a line of uniform elevation (perpendicular to the direction of flow). It can be used at the outer boundary of the work area. However, the fence does not have to surround the

work area completely. In addition, a silt fence is effective where sheet and rill erosion may be a problem. Silt fences should not be constructed in streams or swales.

What to Consider

A silt fence is not appropriate for a large area or where the flow rate is greater than 0.5 cfs. This type of fence can be more effective than a straw bale barrier if properly installed and maintained. It may be used in combination with other erosion and sediment practices.

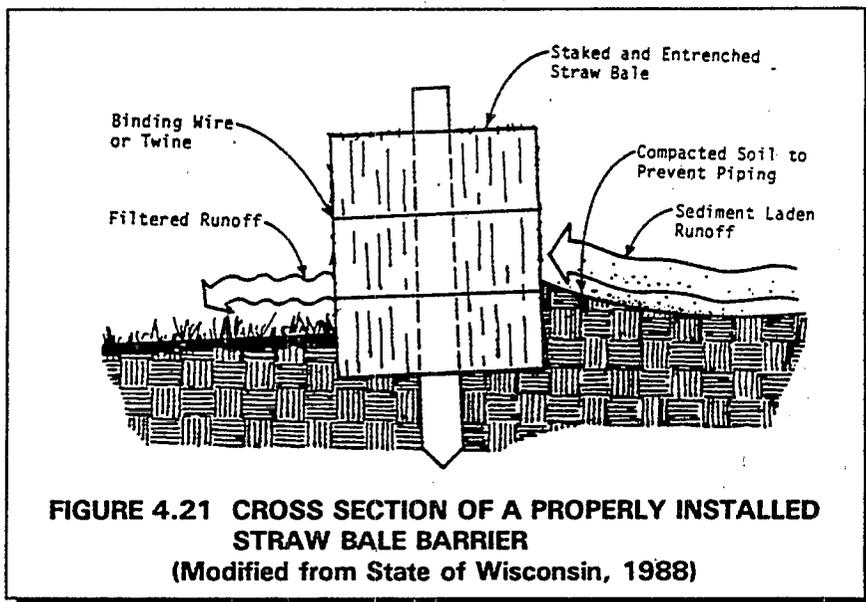
The effective life span for a silt fence is approximately 6 months. During this period, the fence requires frequent inspection and prompt maintenance to maintain its effectiveness. Inspect the fence after each rainfall. Check for areas where runoff eroded a channel beneath the fence, or where the fence was caused to sag or collapse by runoff flowing over the top. Remove and properly dispose of sediment when it is one-third to one-half the height of the fence or after each storm.

| Advantages of a Filter Fence |
|--|
| <ul style="list-style-type: none">• Removes sediments and prevents downstream damage from sediment deposits• Reduces the speed of runoff flow• Minimal clearing and grubbing required for installation• Inexpensive |
| Disadvantages of a Filter Fence |
| <ul style="list-style-type: none">• May result in failure from improper choice of pore size in the filter fabric or improper installation• Should not be used in streams• Is only appropriate for small drainage areas with overland flow• Frequent inspection and maintenance is necessary to ensure effectiveness |

Straw Bale Barrier

What Is It

Straw bales can be used as a temporary sediment barrier. They are placed end to end in a shallow excavated trench (with no gaps in between) and staked into place. If properly installed, they can detain sediment and reduce flow velocity from small drainage areas. A straw bale barrier prevents sediment from leaving the site by trapping the sediment in the barrier while allowing the runoff to pass through. It can also be used to decrease the velocity of sheetflow or channel flows of low-to-moderate levels.



When and Where to Use It

A straw bale barrier should be installed prior to major soil disturbance in the drainage area. This type of barrier is placed perpendicular to the flow, across the bottom of a slope or minor drainageway where there is sheetflow. It can be used at the perimeter of the work area, although it does not have to surround it completely. It can also be very effective when used in combination with other erosion and sediment control practices. A straw bale barrier may be used where the length of slope behind the barrier is less than 100 feet and where the slope is less than 2:1.

What to Consider

The success of a straw bale barrier depends on proper installation. The bales must be firmly staked into the entrenchment and the entrenchment must be properly backfilled. To function effectively, the bales must be placed end to end and there can be no gaps between the bales.

Straw bale barriers are useful for approximately 3 months. They must be inspected and repaired immediately after each rainfall or daily if there is prolonged rainfall. Damaged straw bales require

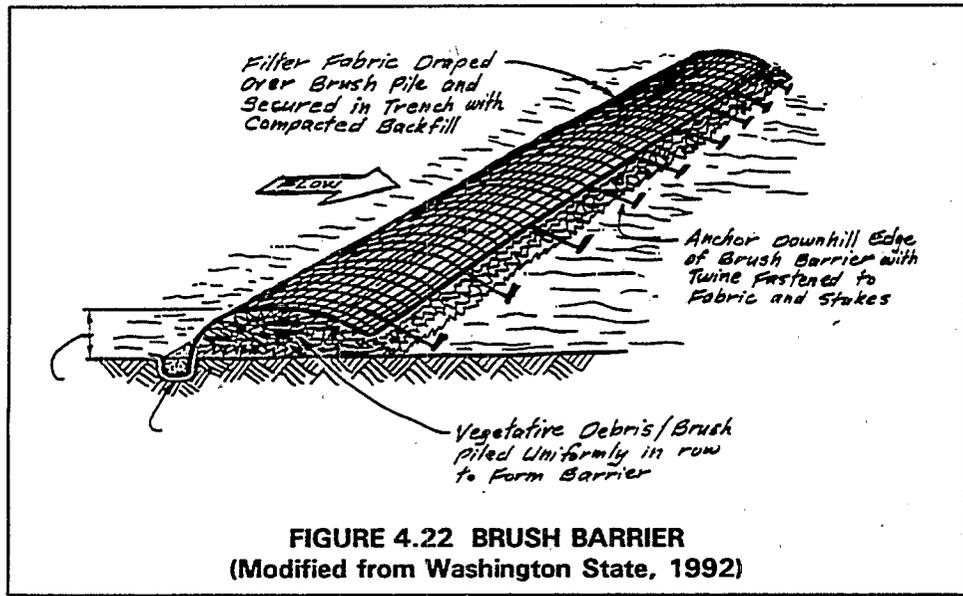
immediate replacement. After each storm, or on a regular basis, trapped sediments must be removed and disposed of properly.

| Advantages of a Straw Bale Barrier |
|--|
| <ul style="list-style-type: none">• Can prevent downstream damage from sediment deposits if properly installed, used, and maintained• Can be an inexpensive way to reduce or prevent erosion |
| Disadvantages of a Straw Bale Barrier |
| <ul style="list-style-type: none">• May not be used in streams or large swales• Poses a risk of washouts if the barrier is installed improperly or a storm is severe• Has a short life span and a high inspection and maintenance requirement• Is appropriate for only small drainage areas• Is easily subject to misuse and can contribute to sediment problems |

Brush Barrier

What Is It

A brush barrier is a temporary sediment barrier constructed from materials resulting from onsite clearing and grubbing. It is usually constructed at the bottom perimeter of the disturbed area. Filter fabric is sometimes used as an anchor over the barrier to increase its filtering efficiency. Brush barriers are used to trap and retain small amounts of sediment by intercepting the flow from small areas of soil disturbance.



When and Where to Use It

A brush barrier should only be used to trap sediment from runoff which is from a small drainage area. The slope which the brush barrier is placed across should be very gentle. Do not place a brush barrier in a swale or any other channel. Brush barriers should be constructed below areas subject to erosion.

What to Consider

The construction of a brush barrier should be started as soon as clearing and grubbing has produced enough material to make the structure. Wood chips should not be included in the material used for the barrier because of the possibility of leaching. When the site has been stabilized and any excess sediment has been disposed of properly, the filter fabric can be removed. Over time, natural vegetation will establish itself within the barrier, and the barrier itself will decompose.

You will not have to maintain the brush barrier unless there is a very large amount of sediment being deposited. If used, the filter fabric anchor should be checked for tears and the damaged

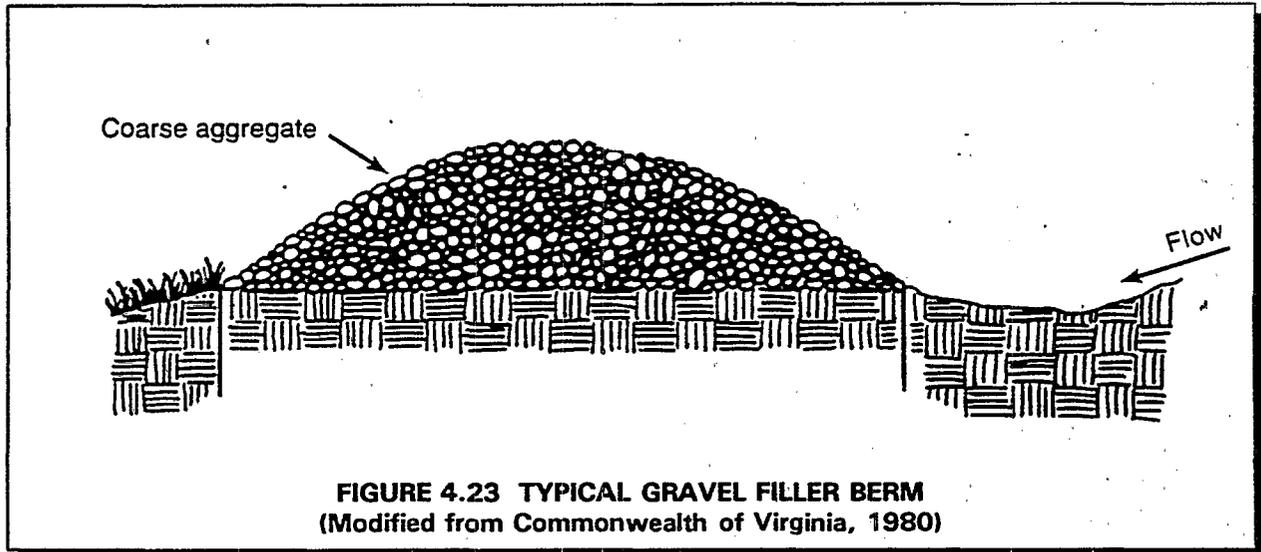
sections replaced promptly. The barrier should be inspected after each rainfall and checked for areas breached by concentrated flow. If necessary, repairs should be made promptly and excess sediment removed and disposed of properly.

| Advantages of a Brush Barrier |
|---|
| <ul style="list-style-type: none">• Can help prevent downstream damage from sediment deposits• Is constructed of cleared onsite materials and, thus, is inexpensive• Usually requires little maintenance, unless there are very heavy sediment deposits |
| Disadvantages of a Brush Barrier |
| <ul style="list-style-type: none">• Does not replace a sediment trap or basin• Is appropriate for only small drainage areas• Has very limited sediment retention |

Gravel or Stone Filter Berm

What Is It

A gravel or stone filter berm is a temporary ridge constructed of loose gravel, stone, or crushed rock. It slows and filters flow, diverting it from an exposed traffic area. Diversions constructed of compacted soil may be used where there will be little or no construction traffic within the right-of-way. They are also used for directing runoff from the right-of-way to a stabilized outlet.



When and Where to Use It

This method is appropriate where roads and other rights-of-way under construction should accommodate vehicular traffic. Berms are meant for use in areas with shallow slopes. They may also be used at traffic areas within the construction site.

What to Consider

Berm material should be well graded gravel or crushed rock. The spacing of the berms will depend on the steepness of the slope: berms should be placed closer together as the slope increases. The diversion should be inspected daily, after each rainfall, or if breached by construction or other vehicles. All needed repairs should be performed immediately. Accumulated sediment should be removed and properly disposed of and the filter material replaced, as necessary.

Advantages of a Gravel or Stone Filter Berm

- Is a very efficient method of sediment control

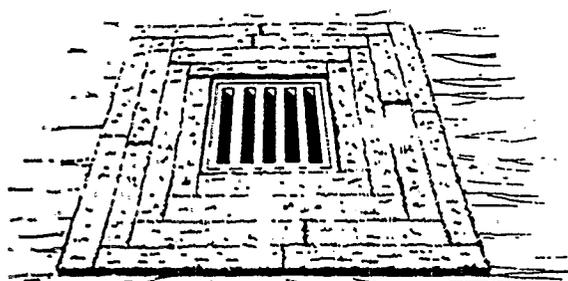
Disadvantages of a Gravel or Stone Filter Berm

- Is more expensive than methods that use onsite materials
- Has a very limited life span
- Can be difficult to maintain because of clogging from mud and soil on vehicle tires

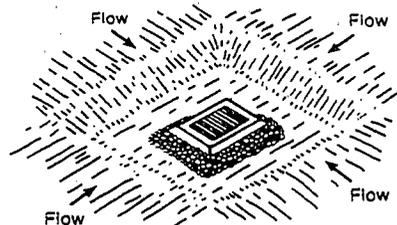
Storm Drain Inlet Protection

What Is It

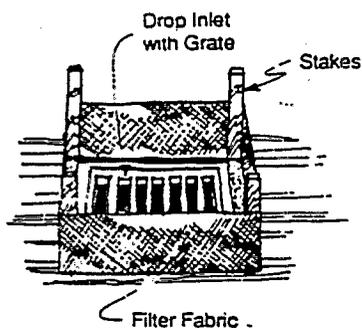
Storm drain inlet protection is a filtering measure placed around any inlet or drain to trap sediment. This mechanism prevents the sediment from entering inlet structures. Additionally, it serves to prevent the silting-in of inlets, storm drainage systems, or receiving channels. Inlet protection may be composed of gravel and stone with a wire mesh filter, block and gravel, filter fabric, or sod.



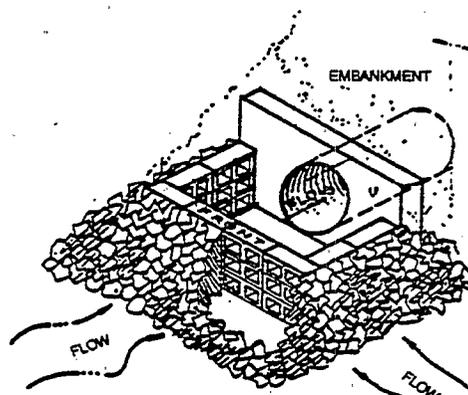
Sod Inlet Protection



Excavated Gravel Inlet Protection



Filter Fabric Inlet Protection



Block and Gravel Inlet Protection

FIGURE 4.24 EXAMPLES OF STORM DRAIN INLET PROTECTION

(Modified from State of North Carolina, 1988; Washington State, 1992; and County of Fairfax, 1987)

When and Where to Use It

This type of protection is appropriate for small drainage areas where storm drain inlets will be ready for use before final stabilization. Storm drain inlet protection is also used where a permanent storm drain structure is being constructed onsite. Straw bales are not recommended for this purpose. Filter fabric is used for inlet protection when storm water flows are relatively small with low velocities. This practice cannot be used where inlets are paved because the filter fabric should be staked. Block and gravel filters can be used where velocities are higher. Gravel and mesh filters

can be used where flows are higher and subject to disturbance by site traffic. Sod inlet filters are generally used where sediments in the storm water runoff are low.

What to Consider

Storm drain inlet protection is not meant for use in drainage areas exceeding 1 acre or for large concentrated storm water flows. Installation of this measure should take place before any soil disturbance in the drainage area. The type of material used will depend on site conditions and the size of the drainage area. Inlet protection should be used in combination with other measures, such as small impoundments or sediment traps, to provide more effective sediment removal. Inlet protection structures should be inspected regularly, especially after a rainstorm. Repairs and silt removal should be performed as necessary. Storm drain inlet protection structures should be removed only after the disturbed areas are completely stabilized.

Advantages of Storm Drain Inlet Protection

- Prevents clogging of existing storm drainage systems and the siltation of receiving waters
- Reduces the amount of sediment leaving the site

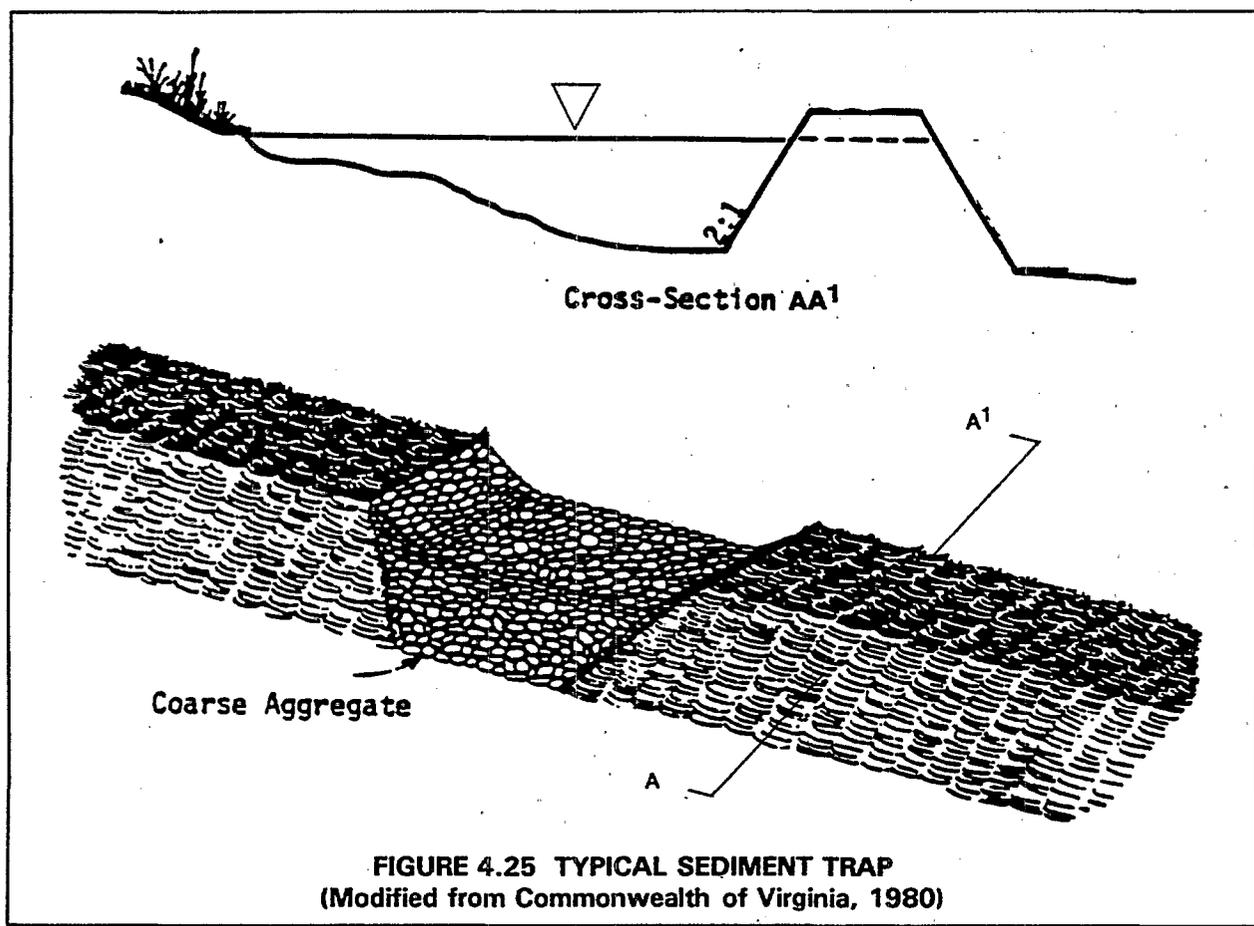
Disadvantages of Storm Drain Inlet Protection

- May be difficult to remove collected sediment
- May cause erosion elsewhere if clogging occurs
- Is practical only for low sediment, low volume flows

Sediment Trap

What Is It

A sediment trap is formed by excavating a pond or by placing an earthen embankment across a low area or drainage swale. An outlet or spillway is constructed using large stones or aggregate to slow the release of runoff. The trap retains the runoff long enough to allow most of the silt to settle out.



When and Where to Use It

A temporary sediment trap may be used in conjunction with other temporary measures, such as gravel construction entrances, vehicle wash areas, slope drains, diversion dikes and swales, or diversion channels. This device is appropriate for sites with short time schedules.

What to Consider

Sediment traps are suitable for small drainage areas, usually no more than 10 acres, that have no unusual drainage features. The trap should be large enough to allow the sediments to settle and should have a capacity to store the collected sediment until it is removed. The volume of storage required depends upon the amount and intensity of expected rainfall and on estimated quantities of sediment in the storm water runoff. Check your Permit to see if it specifies a minimum storage volume for sediment traps.

A sediment trap is effective for approximately 18 months. During this period, the trap should be readily accessible for periodic maintenance and sediment removal. Traps should be inspected after each rainfall and cleaned when no more than half the design volume has been filled with collected sediment. The trap should remain in operation and be properly maintained until the site area is permanently stabilized by vegetation and/or when permanent structures are in place.

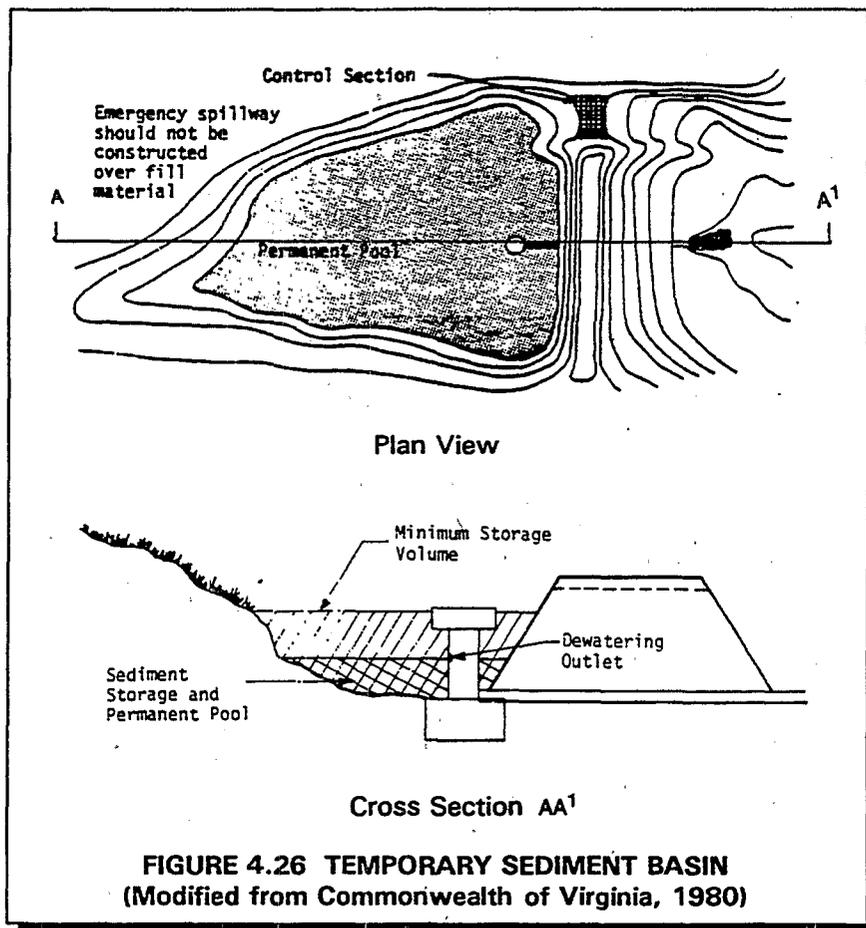
| Advantages of a Sediment Trap |
|---|
| <ul style="list-style-type: none">• Protects downstream areas from clogging or damage due to sediment deposits• Is inexpensive and simple to install• Can simplify the design process by trapping sediment at specific spots onsite |
| Disadvantages of a Sediment Trap |
| <ul style="list-style-type: none">• Is suitable only for a limited area• Is effective only if properly maintained• Will not remove very fine silts and clays• Has a short life span |

Temporary Sediment Basin

What Is It

A temporary sediment basin is a settling pond with a controlled storm water release structure used to collect and store sediment produced by construction activities. A sediment basin can be constructed by excavation or by placing an earthen embankment across a low area or drainage swale. Sediment basins can be designed to maintain a permanent pool or to drain completely dry. The basin detains sediment-laden runoff from larger drainage areas long enough to allow most of the sediment to settle out.

The pond has a gravel outlet or spillway to slow the release of runoff and provide some sediment filtration. By removing sediment, the basin helps prevent clogging of offsite conveyance systems and sediment-loading of receiving waterways. In this way, the basin helps prevent destruction of waterway habitats.



When and Where to Use It

A temporary sediment basin should be installed before clearing and grading is undertaken. It should not be built on an embankment in an active stream. The creation of a dam in such a site may result in the destruction of aquatic habitats. Dam failure can also result in flooding. A temporary sediment basin should be located only where there is sufficient space and appropriate topography. The basin should be made large enough to handle the maximum expected amount of site drainage. Fencing around the basin may be necessary for safety or vandalism reasons.

A temporary sediment basin used in combination with other control measures, such as seeding or mulching, is especially effective for removing sediments.

What to Consider

Temporary sediment basins are usually designed for disturbed areas larger than 5 acres. The pond should be large enough to hold runoff long enough for sediment to settle. Sufficient space should be allowed for collected sediments. Check the requirements of your permit to see if there is a minimum storage requirement for sediment basins. The useful life of a temporary sediment basin is about 12 to 18 months.

Sediment trapping efficiency is improved by providing the maximum surface area possible. Because finer silts may not settle out completely, additional erosion control measures should be used to minimize release of fine silt. Runoff should enter the basin as far from the outlet as possible to provide maximum retention time.

Sediment basins should be readily accessible for maintenance and sediment removal. They should be inspected after each rainfall and be cleaned out when about half the volume has been filled with sediment. The sediment basin should remain in operation and be properly maintained until the site area is permanently stabilized by vegetation and/or when permanent structures are in place. The embankment forming the sedimentation pool should be well compacted and stabilized with vegetation. If the pond is located near a residential area, it is recommended for safety reasons that a sign be posted and that the area be secured by a fence. A well built temporary sediment basin that is large enough to handle the post construction runoff volume may later be converted to use as a permanent storm water management structure.

Advantages of a Temporary Sediment Basin

- Protects downstream areas from clogging or damage due to sediment deposits generated during construction activities
- Can trap smaller sediment particles than sediment traps can because of the longer detention time

Disadvantages of a Temporary Sediment Basin

- Is generally suitable for small areas
- Requires regular maintenance and cleaning
- Will not remove very fine silts and clays unless used in conjunction with other measures
- Is a more expensive way to remove sediment than several other methods
- Requires careful adherence to safety practices since ponds are attractive to children

Outlet Protection

What Is It

Outlet protection reduces the speed of concentrated storm water flows and therefore it reduces erosion or scouring at storm water outlets and paved channel sections. In addition, outlet protection lowers the potential for downstream erosion. This type of protection can be achieved through a variety of techniques, including stone or riprap, concrete aprons, paved sections and settling basins installed below the storm drain outlet.

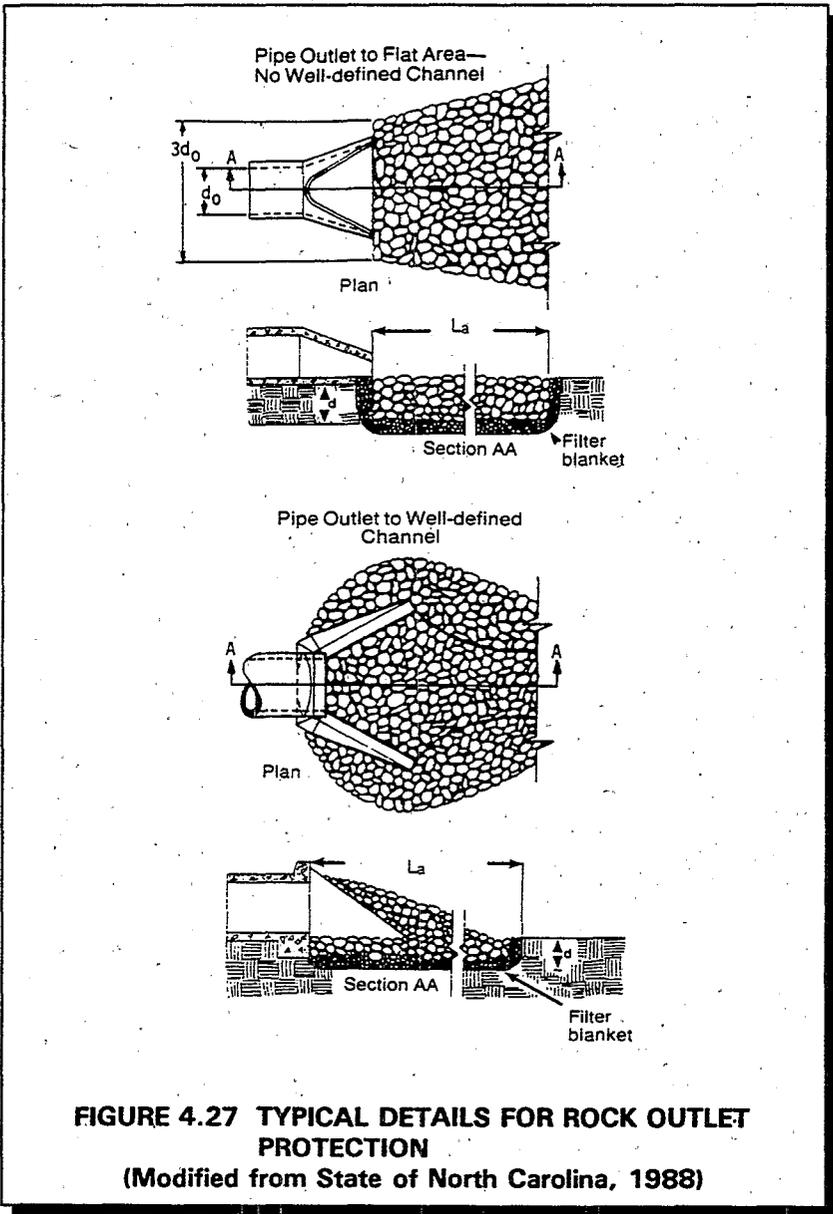


FIGURE 4.27 TYPICAL DETAILS FOR ROCK OUTLET PROTECTION
(Modified from State of North Carolina, 1988)

When and Where to Use It

Outlet protection should be installed at all pipe, interceptor dike, swale, or channel section outlets where the velocity of flow may cause erosion at the pipe outlet and in the receiving channel. Outlet protection should also be used at outlets where the velocity of flow at the design capacity may result in plunge pools (small permanent pools located at the inlet to or the outfall from BMPs). Outlet protection should be installed early during construction activities, but may be added at any time, as necessary.

What to Consider

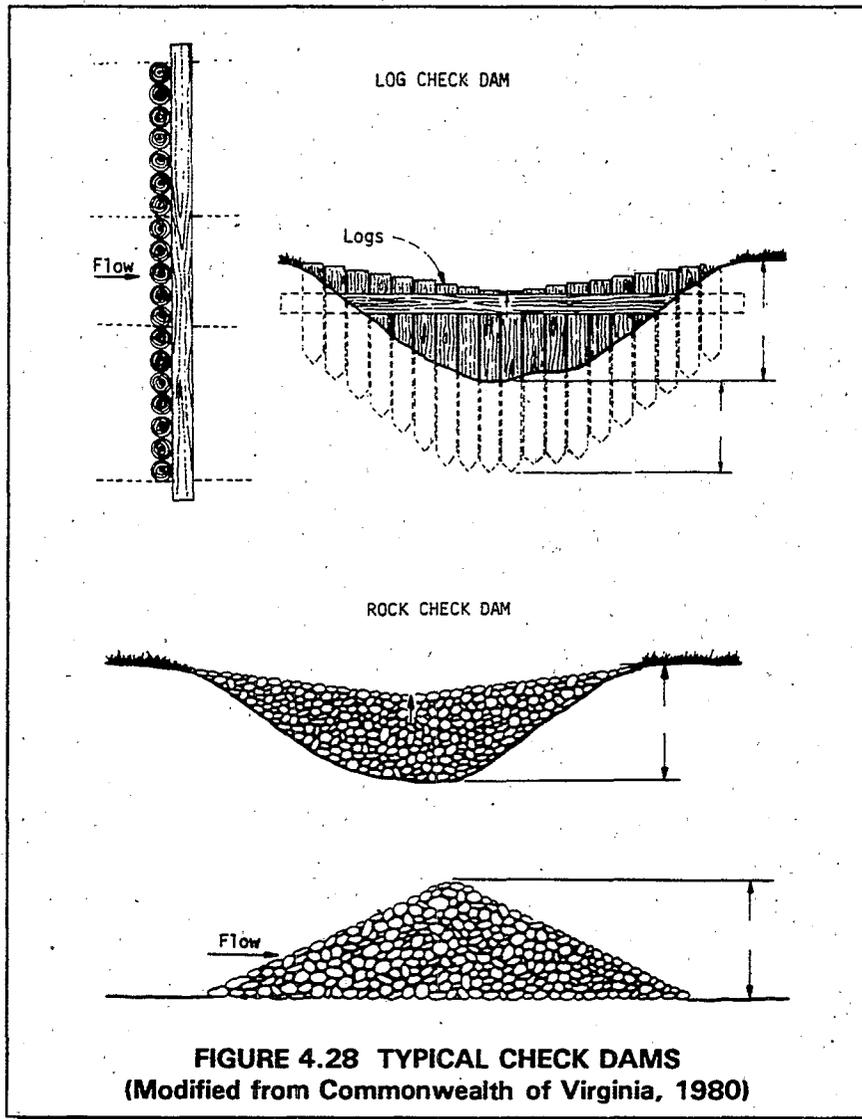
The exit velocity of the runoff as it leaves the outlet protection structure should be reduced to levels that minimize erosion. Outlet protection should be inspected on a regular schedule to look for erosion and scouring. Repairs should be made promptly.

| Advantages of Outlet Protection |
|---|
| <ul style="list-style-type: none">• Provides, with riprap-line apron (the most common outlet protection), a relatively low cost method that can be installed easily on most sites• Removes sediment in addition to reducing flow speed• Can be used at most outlets where the flow speed is high• Is an inexpensive but effective measure• Requires less maintenance than many other measures |
| Disadvantages of Outlet Protection |
| <ul style="list-style-type: none">• May be unsightly• May cause problems in removing sediment (without removing and replacing the outlet protection structure itself)• May require frequent maintenance for rock outlets with high velocity flows |

Check Dams

What Are They

A check dam is a small, temporary or permanent dam constructed across a drainage ditch, swale, or channel to lower the speed of concentrated flows. Reduced runoff speed reduces erosion and gullying in the channel and allows sediments and other pollutants to settle out.



When and Where to Use Them

A check dam should be installed in steeply sloped swales, or in swales where adequate vegetation cannot be established. A check dam may be built from logs, stone, or pea gravel-filled sandbags.

What to Consider

Check dams should be used only in small open channels that drain 10 acres or less. The dams should not be placed in streams (unless approved by appropriate State authorities). The center section of the check dam should be lower than the edges. Dams should be spaced so that the toe of the upstream dam is at the same elevation as the top of the downstream dam.

After each significant rainfall, check dams should be inspected for sediment and debris accumulation. Sediment should be removed when it reaches one half the original dam height. Check for erosion at edges and repair promptly as required. After construction is complete, all stone and riprap should be removed if vegetative erosion controls will be used as a permanent erosion control measure. It will be important to know the expected erosion rates and runoff flow rate for the swale in which this measure is to be installed. Contact the State/local storm water program agency or a licensed engineer for assistance in designing this measure.

| Advantages of Check Dams |
|---|
| <ul style="list-style-type: none">• Are inexpensive and easy to install• May be used permanently if designed properly• Allow a high proportion of sediment in the runoff to settle out• Reduce velocity and provide aeration of the water• May be used where it is not possible to divert the flow or otherwise stabilize the channel |
| Disadvantages of Check Dams |
| <ul style="list-style-type: none">• May kill grass linings in channels if the water level remains high after it rains or if there is significant sedimentation• Are useful only for drainage areas of 10 acres or less |

Surface Roughening

What Is It

Surface roughening is a temporary erosion control practice. The soil surface is roughened by the creation of horizontal grooves, depressions, or steps that run parallel to the contour of the land. Slopes that are not fine-graded and that are left in a roughened condition can also control erosion. Surface roughening reduces the speed of runoff, increases infiltration, and traps sediment. Surface roughening also helps establish vegetative cover by reducing runoff velocity and giving seed an opportunity to take hold and grow.

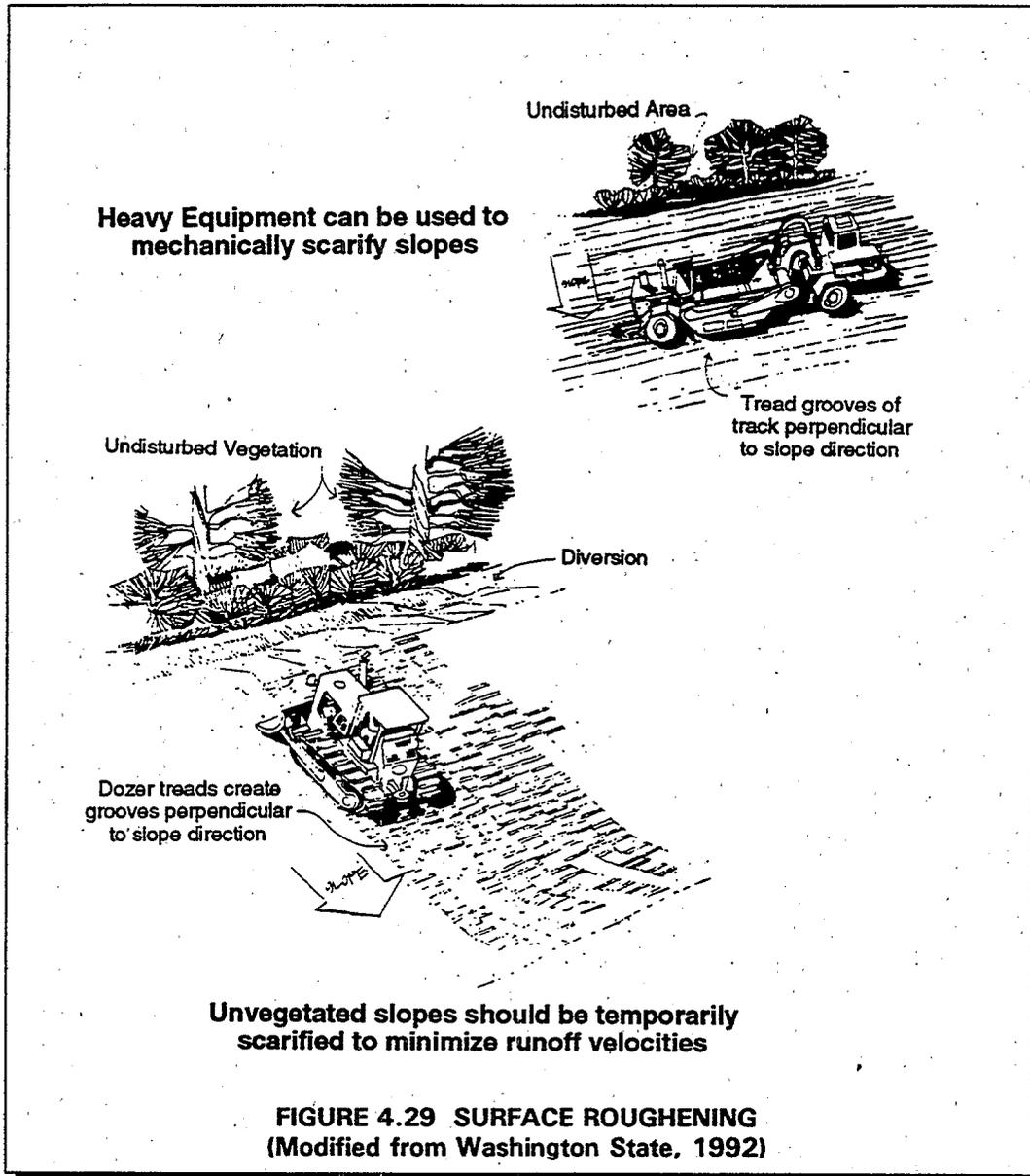


FIGURE 4.29 SURFACE ROUGHENING
(Modified from Washington State, 1992)

When and Where to Use It

Surface roughening is appropriate for all slopes. To slow erosion, roughening should be done as soon as possible after the vegetation has been removed from the slope. Roughening can be used with both seeding and planting and temporary mulching to stabilize an area. For steeper slopes and slopes that will be left roughened for longer periods of time, a combination of surface roughening and vegetation is appropriate.

What to Consider

Different methods can be used to roughen the soil surface on slopes. They include stair-step grading, grooving (using disks, spring harrows, or teeth on a front-end loader), and tracking (driving a crawler tractor up and down a slope, leaving the cleat imprints parallel to the slope contour). The selection of an appropriate method depends on the grade of the slope, mowing requirements after vegetative cover is established, whether the slope was formed by cutting or filling, and type of equipment available.

Cut slopes with a gradient steeper than 3:1 but less than 2:1 should be stair-step graded or groove cut. Stair-step grading works well with soils containing large amounts of small rock. Each step catches material discarded from above and provides a level site where vegetation can grow. Stairs should be wide enough to work with standard earth moving equipment. Grooving can be done by any implement that can be safely operated on the slope, including those described above. Grooves should not be less than 3 inches deep nor more than 15 inches apart. Fill slopes with a gradient steeper than 3:1 but less than 2:1 should be compacted every 9 inches of depth. The face of the slope should consist of loose, uncompacted fill 4 to 6 inches deep that can be left rough or can be grooved as described above, if necessary.

Any cut or filled slope that will be mowed should have a gradient less than 3:1. Such a slope can be roughened with shallow grooves parallel to the slope contour by using normal tilling. Grooves should be close together (less than 10 inches) and not less than 1 inch deep. Any gradient with a slope greater than 2:1 should be stair-stepped.

It is important to avoid excessive compacting of the soil surface, especially when tracking, because soil compaction inhibits vegetation growth and causes higher runoff speed. Therefore, it is best to limit roughening with tracked machinery to sandy soils that do not compact easily and to avoid tracking on clay soils. Surface roughened areas should be seeded as quickly as possible. Also, regular inspections should be made of all surface roughened areas, especially after storms. If rills (small watercourses that have steep sides and are usually only a few inches deep) appear, they should be filled, graded again, and reseeded immediately. Proper dust control procedures should be followed when surface roughening.

Advantages of Surface Roughening

- Provides a degree of instant erosion protection for bare soil while vegetative cover is being established
- Is inexpensive and simple for short-term erosion control

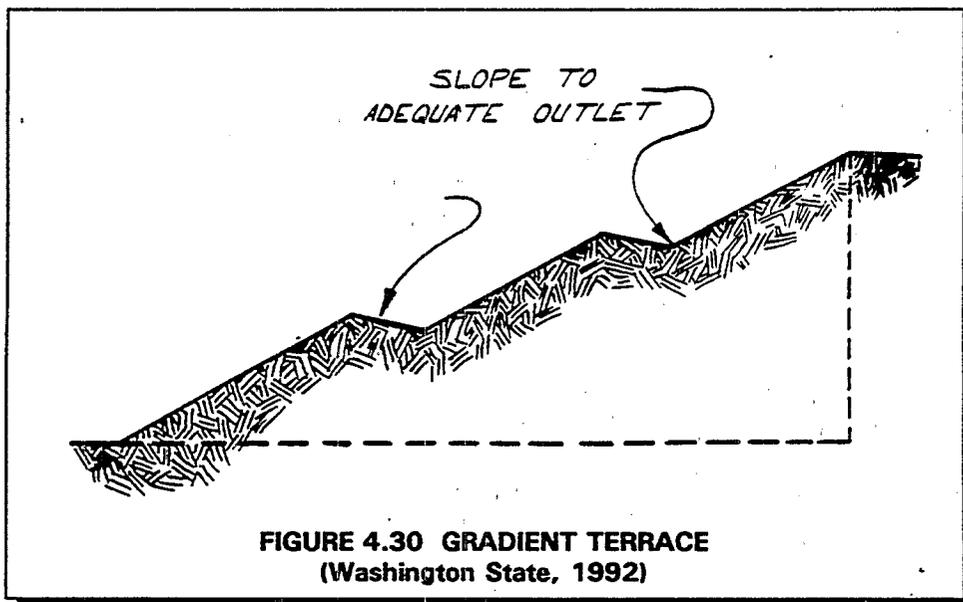
Disadvantages of Surface Roughening

- Is of limited effectiveness in anything more than a gentle rain
- Is only temporary; if roughening or vegetative cover is washed away in a heavy storm or the vegetation does not take hold, the surface will have to be re-roughened and new seed laid

Gradient Terraces

What Are They

Gradient terraces are earth embankments or ridge-and-channels constructed with suitable spacing and with an appropriate grade. They reduce erosion damage by capturing surface runoff and directing it to a stable outlet at a speed that minimizes erosion.



When and Where to Use Them

Gradient terraces are usually limited to use on land that has no vegetation and that has a water erosion problem, or where it is anticipated that water erosion will be a problem. Gradient terraces should not be constructed on slopes with sandy or rocky soils. They will be effective only where suitable runoff outlets are or will be made available.

What to Consider

Gradient terraces should be designed and installed according to a plan determined by an engineering survey and layout. It is important that gradient terraces are designed with adequate outlets, such as a grassed waterway, vegetated area, or tile outlet. In all cases, the outlet should direct the runoff from the terrace system to a point where the outflow will not cause erosion or other damage. Vegetative cover should be used in the outlet where possible. The design elevation of the water surface of the terrace should not be lower than the design elevation of the water surface in the outlet at their junction, when both are operating at design flow. Terraces should be inspected regularly at least once a year and after major storms. Proper dust control procedures should be followed while constructing these features.

Advantages of Gradient Terraces

- Reduce runoff speed and increase the distance of overland runoff flow
- Hold moisture better than do smooth slopes and minimize sediment loading of surface runoff

Disadvantages of Gradient Terraces

- May significantly increase cut and fill costs and cause sloughing if excessive water infiltrates the soil
- Are not practical for sandy, steep, or shallow soils

4.6 INFILTRATION PRACTICES

Infiltration practices are surface or subsurface measures that allow for quick infiltration of storm water runoff. Rapid infiltration is possible because the structures or soils used in these practices are very porous. Infiltration practices offer an advantage over other practices in that they provide some treatment of runoff, preserve the natural flow in streams, and recharge ground water. Many of the infiltration practices also can reduce the velocity of the runoff so that it will not cause damaging erosion. Another benefit of infiltration practices is that they reduce the need for expensive storm water conveyance systems. Construction and maintenance of these practices may, however, require some level of expertise to prevent clogging and to retain high effectiveness. The infiltration practices in this section have been divided into two categories: vegetative infiltration practices and infiltration structures.

Infiltration BMPs are not practical in all cases. These practices should not be used in areas where runoff is contaminated with pollutants other than sediment or oil and grease. Excessively drained (i.e., very sandy) soils may provide inadequate treatment of runoff, which could result in ground water contamination. Other site-specific conditions, such as depth to bedrock or depth to the water table, could limit their use or make it impossible to use infiltration BMPs. Also, infiltration practices should not be installed near wells, foundations, septic tank drainfields, or on unstable slopes.

Vegetative infiltration practices rely on vegetated soils that are well drained to provide storage for the infiltration of storm water. Soils used for this practice generally have not previously been disturbed or compacted so that they more easily allow infiltration. Once vegetation has been planted, use of the area must be limited or the practice may not operate efficiently. The practices that are discussed include vegetated filter strips, grassed swales, and level spreaders.

Infiltration structures are built over soils to aid in collection of storm water runoff and are designed to allow storm water to infiltrate into the ground. These structures generally require a level of expertise for both their design and construction so that they function properly. Maintenance activities are very important because infiltration structures are easily damaged by high sediment loads. Often, infiltration structures are used with other structures that pretreat the storm water runoff for sediments, oil, and grease. These pretreatment structures may be as simple as a buffer zone (see Buffer Zones) or may be something more complex, such as an oil and grease separator. The types of infiltration structures discussed include infiltration trenches, porous pavements, concrete grids, and modular pavements.

Vegetated Filter Strips

What Are They

Vegetated filter strips are gently sloping areas of natural vegetation or are graded and artificially planted areas used to provide infiltration, remove sediments and other pollutants, and reduce the flow and velocity of the storm water moving across the terrain. Vegetated filter strips function similarly to vegetated or grassed swales. The filter strips, however, are fairly level and treat sheetflow, whereas grassed swales are indentations (see section on Grassed Swales) and treat concentrated flows. Vegetated filter strips provide permanent storm water control measures on a site.

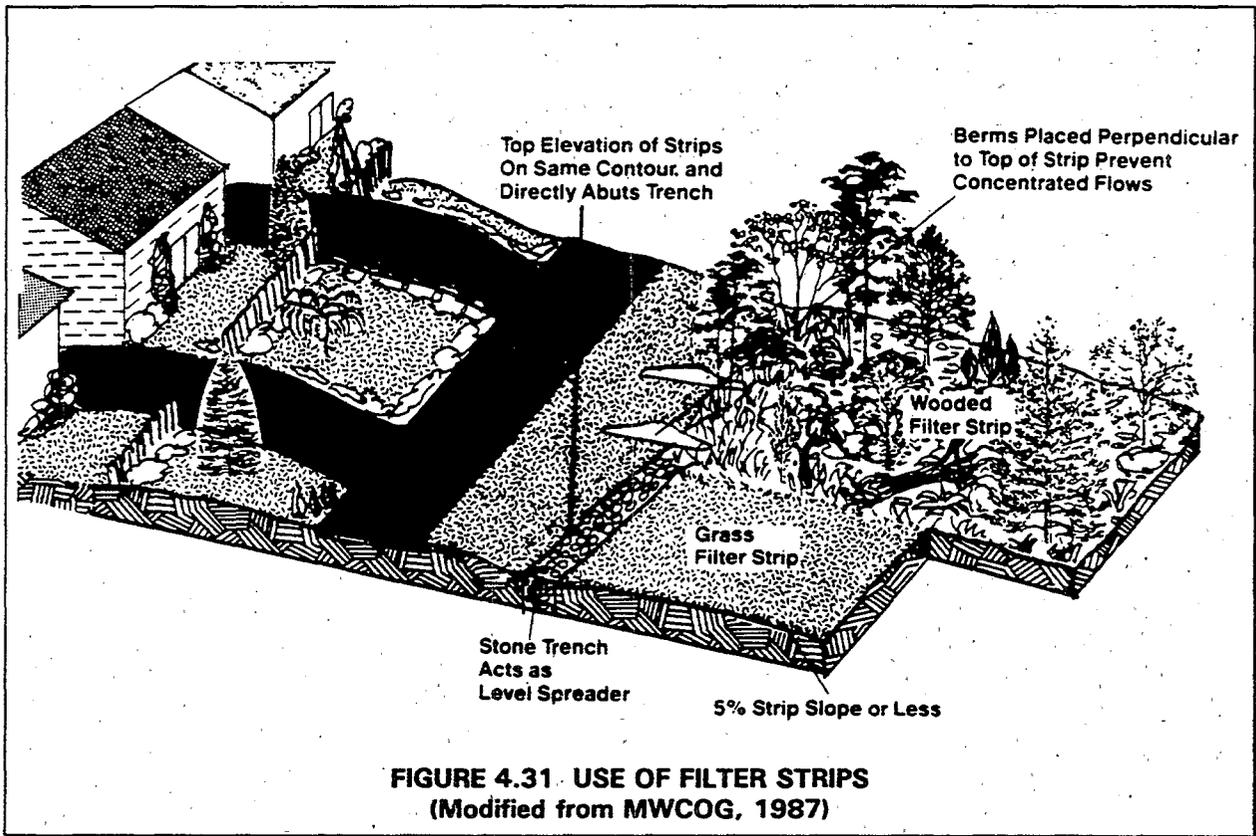


FIGURE 4.31 USE OF FILTER STRIPS
(Modified from MWCOG, 1987)

When and Where to Use Them

Vegetated filter strips are suited for areas where the soils are well drained or moderately well drained and where the bedrock and the water table are well below the surface. Vegetated filter strips will not function well on steep slopes, in hilly areas, or in highly paved areas because of the high velocity of runoff. Sites with slopes of 15 percent or more may not be suitable for filtering storm water flows. However, they should still be vegetated (MWCOG, 1987). This practice can be put into place at any time, provided that climatic conditions allow for planting.

What to Consider

At a minimum, a filter strip must be approximately 20 feet wide to function well. The length of the strip should be approximately 50 to 75 feet. Where slopes become steeper, the length of the strip must be increased. Forested strips are always preferred to vegetated strips, and existing vegetation is preferred to planted vegetation. In planning for vegetated strips, consider climatic conditions, since vegetation may not take hold in especially dry and/or cold regions.

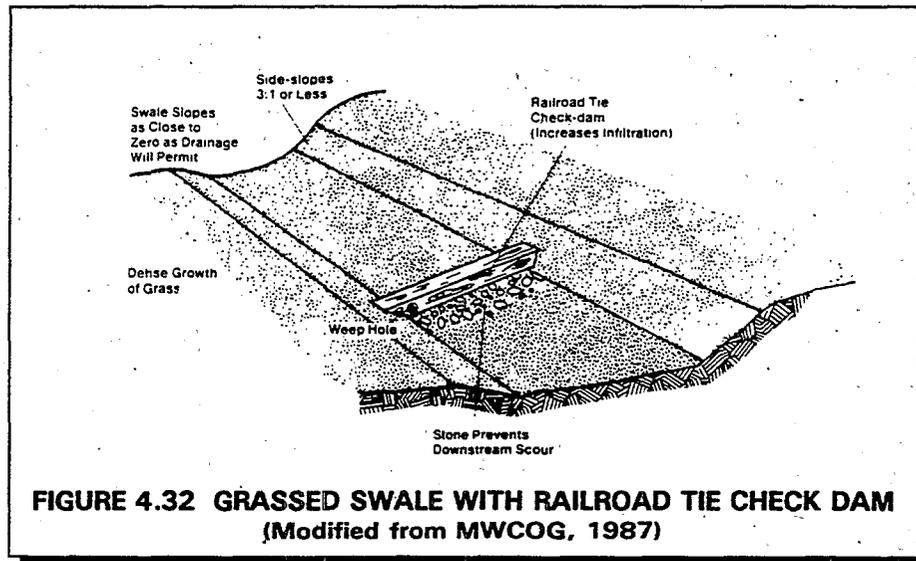
Regular inspections are necessary to ensure the proper functioning of the filter strips. Removing sediments and replanting may be necessary on a regular basis. The entire area should be examined for damage due to equipment and vehicles. Vegetation should be dense. Also, the portions of the strip where erosion may have created ponding of runoff should be inspected. This situation can be eliminated by grading.

| Advantages of Vegetated Filter Strips |
|---|
| <ul style="list-style-type: none">• Provide low to moderate treatment of pollutants in storm water while providing a natural look to a site• Can provide habitat for wildlife• Can screen noise and views if trees or high shrubs are planted on the filter strips• Are easily constructed and implemented• Are inexpensive |
| Disadvantages of Vegetated Filter Strips |
| <ul style="list-style-type: none">• Are not effective for high velocity flows (large paved areas or steep slopes)• Require significant land space• May have a short useful life due to clogging by sediments and oil and grease |

Grassed Swales

What Are They

Grassed swales are vegetated depressions used to transport, filter, and remove sediments. Grassed swales control high runoff rates by reducing the speed of the runoff and by reducing the volume of the runoff through infiltration of the storm water. Pollutants are removed because runoff travels slowly and infiltrates into the soil and because the vegetation in the grassed swale works as a filter or strainer.



When and Where to Use Them

Grassed swales are suitable for most areas where storm water runoff is low. Certain factors will affect the operation of grassed swales, including soil type, land features, and the depth of the soil from the surface to the water table (i.e., the top of the drenched portion of the soil or bedrock layer). The soil must be permeable for runoff to be able to infiltrate well. Sandy soils will not hold vegetation well nor form a stable channel structure. Steep slopes will increase runoff rates and create greater potential for erosion. Storm water flows will not be easily absorbed where the water table is near the surface. Swales are most useful for sites smaller than 10 acres (MWCOG, 1987). Even without highly permeable soils, swales reduce velocity and thus are useful.

Grassed swales usually do not work well for construction runoff because the runoff has high sediment loads.

What to Consider

The channel of the swale should be as level as possible to maximize infiltration. Side slopes in the swale should be designed to no steeper than 3:1 to minimize channel erosion (MWCOG, 1987). Plans should consider (1) the use of existing topography and existing drainage patterns and (2) the

highest flow rate that is expected from a typical storm to determine the most practical size for the swale (in keeping with State or local requirements).

The swale should be tilled before grass is planted, and a dense cover of grasses should be planted in the swale. The location of the swale will determine the best type of vegetation (e.g., if the swale runs next to a road, then the grass chosen should be resistant to the use of de-icing salts in northern states).

Check dams (i.e., earthen or log structures) may be installed in the swales to reduce runoff speed and increase infiltration. Planners should also consider the design of the outlet at the end of the swale so that the runoff is released from the swale at a low rate (see section on Outlet Protection).

Maintenance activities for the swales include those practices needed to maintain healthy, dense vegetation and to retain efficient infiltration and movement of the storm water into and through the swale. Periodic mowing, reseeding, and weed control are required to maintain pollutant removal efficiency. The swale and channel outlet should be kept free from sediment-buildup, litter, brush, or fallen tree limbs.

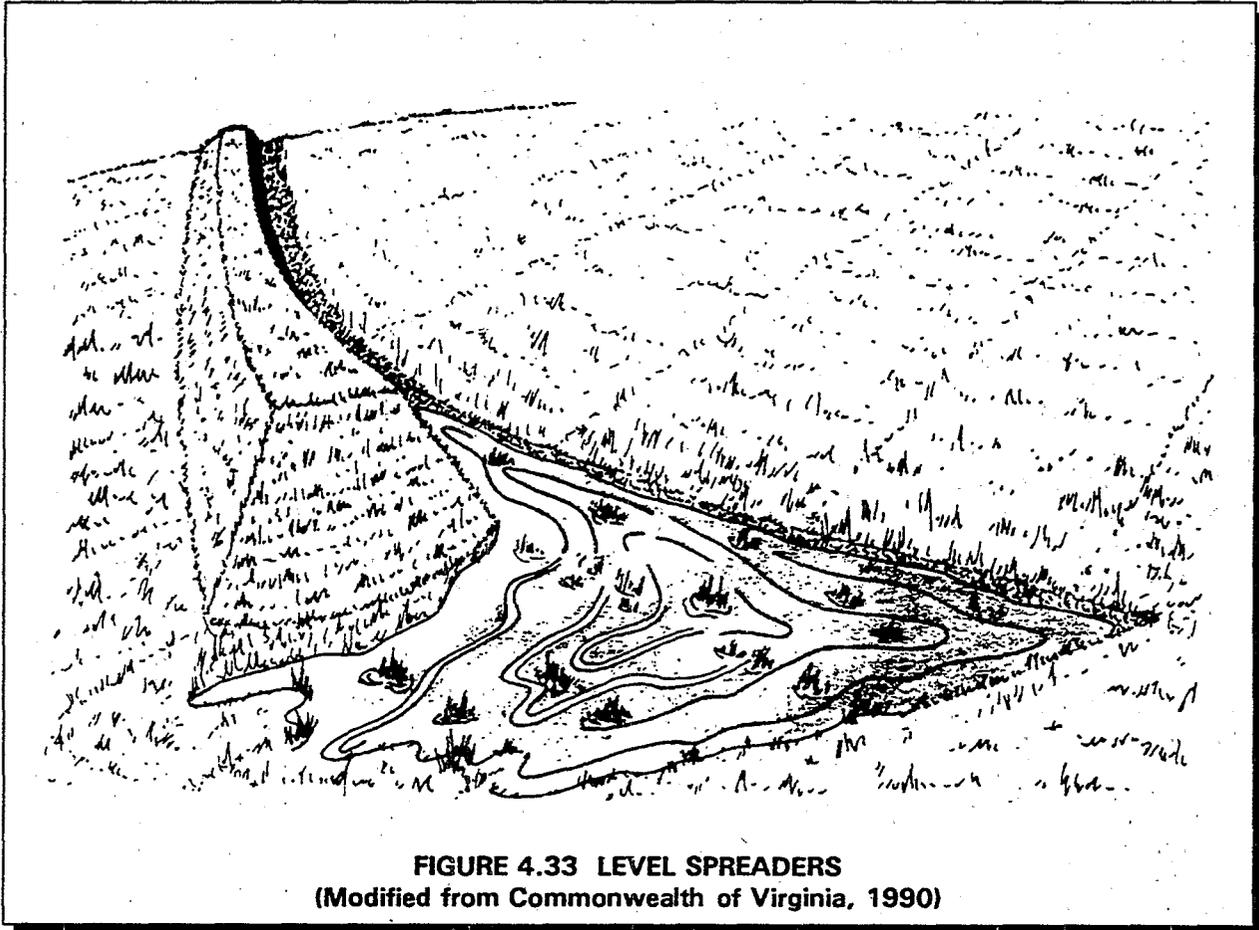
Periodic inspections will identify erosion problems or damaged areas. Damaged or eroded areas of the channel should be repaired. Areas with damaged vegetation should be reseeded immediately.

| Advantages of Grassed Swales |
|--|
| <ul style="list-style-type: none">• Are easily designed and constructed• Provide moderate removal of sediments if properly constructed and maintained• May provide a wildlife habitat• Are inexpensive• Can replace curb and gutter systems• Can last for long periods of time if well maintained |
| Disadvantages of Grassed Swales |
| <ul style="list-style-type: none">• Cannot control runoff from very large storms• If they do not drain properly between storms, can encourage nuisance problems such as mosquitos, ragweed, dumping, and erosion• Are not capable of removing significant amounts of soluble nutrients• Cannot treat runoff with high sediment loadings |

Level Spreaders

What Are They

Level spreaders are devices used at storm water outlets to spread out collected storm water flows into sheetflow (runoff that flows over ground surface in a thin, even layer). Typically, a level spreader consists of a depression in the soil surface that spreads the flow onto a flat area across a gentle slope. Level spreaders then release the storm water flow onto level areas stabilized by vegetation to reduce speed and increase infiltration.



When and Where to Use Them

Level spreaders are most often used as an outlet for temporary or permanent storm water conveyances or dikes. Runoff that contains high sediment loads should be treated in a sediment trapping device prior to release into a level spreader.

What to Consider

The length of the spreader depends upon the amount of water that flows through the conveyance. Larger volumes of water need more space to even out. Level spreaders are generally used with filter strips (see Vegetated Filter Strips). The depressions are seeded with vegetation (see Permanent Seeding).

Level spreaders should not be used on soil that might erode easily. They should be constructed on natural soils and not on fill material. The entrance to the spreader should be level so that the flow can spread out evenly.

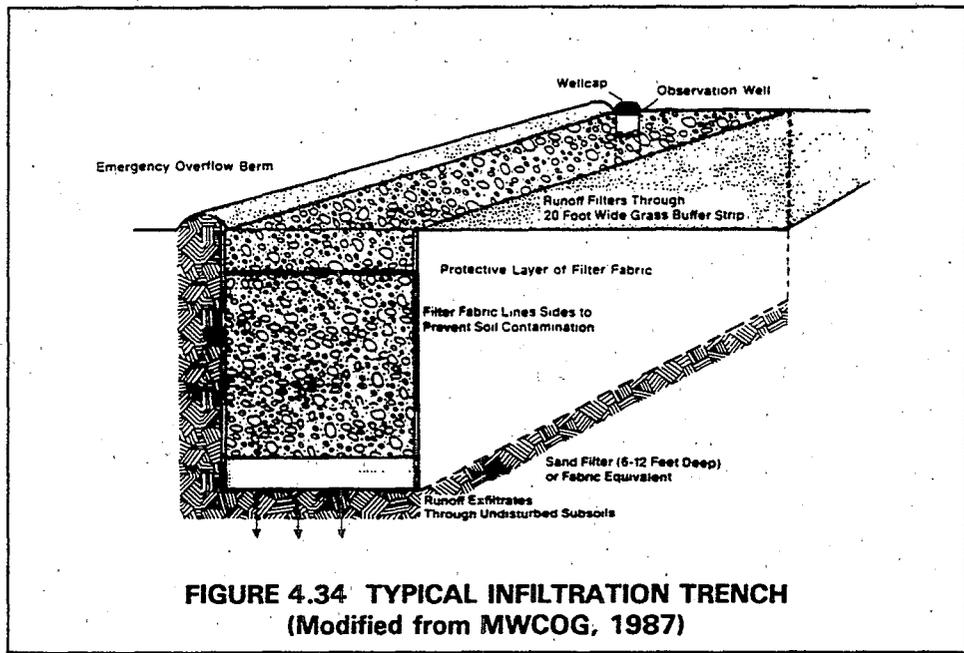
The spreader should be inspected after every large storm event to check for damage. Heavy equipment and other traffic should be kept off the level spreader because these vehicles may compact the soil or disturb the grade of the slope. If ponding or erosion channels develop, the spreader should be regraded. Dense vegetation should be maintained and damaged areas reseeded as needed.

| Advantages of Level Spreaders |
|---|
| <ul style="list-style-type: none">• Reduce storm water flow velocity, encourage sedimentation and infiltration• Are relatively inexpensive to install |
| Disadvantages of Level Spreaders |
| <ul style="list-style-type: none">• Can easily develop "short circuiting" (concentration of flows into small streams instead of sheetflow over the spreader) because of erosion or other disturbance• Cannot handle large quantities of sediment-laden storm water |

Infiltration Trenches

What Are They

An infiltration trench usually consists of a long, narrow excavation ranging from 3 to 12 feet deep. The trench is filled with stone, which allows for temporary storage of storm water runoff in the open spaces between the stones. The stored storm water infiltrates into the surrounding soil or drains into underground pipes through holes and is then routed to an outflow point. Infiltration trenches are designed to remove both fine sediments and soluble pollutants rather than larger, coarse pollutants.



When and Where to Use Them

Infiltration trenches should be restricted to areas with certain soil, ground water, slope, area, and pollutant conditions. For example, infiltration trenches will not operate well in soils that have high clay contents, silt/clay soils, sandy/clay loams, or soils that have been compacted. Trenches should not be sited over fill soils because such soils are unstable. Hardened soils are often not suitable for infiltration trenches because these types of soils do not easily absorb water. Infiltration practices in general should not be used to manage contaminated storm water.

The drainage area contributing runoff to a single trench should not exceed 5 acres (State of Maryland, 1983). Construction of trenches should not start until after all land-disturbing activities have ceased so that runoff with high levels of sediment does not fill in the structure.

If slopes draining into the trench are steeper than 5 percent, the runoff will enter the trench too fast and will overwhelm the infiltration capacity of the soil, causing overflow. The depth from the bottom of the trench to the bedrock layer and the seasonal high water table must be at least three feet. Infiltration trenches may not be suitable in areas where there are cold winters and deep frost levels.

What to Consider

Pretreatment of runoff before it is channeled to the trench is important to efficient operation because pretreatment removes sediment, grit, and oil. Reducing the pollutant load in the runoff entering the trench lengthens trench life. One method of pretreatment is to install a buffer zone just above the trench to act as a filter (see Buffer Zones). In addition, a layer of filter fabric 1 foot below the bottom of the trench can be used to trap the sediments that get through the buffer strip. If excavation around the trenches is necessary, the use of light duty equipment will avoid compacting, which could cause a loss of infiltration capability.

Infiltration trenches should be inspected at least once per year and after major rainfall events. Debris should be removed from all areas of the trench, especially the inlets and overflow channels. Dense vegetative growth should be maintained in buffer areas surrounding the trench.

Test wells can be installed in every trench to monitor draining times and provide information on how well the system is operating. Daily test well monitoring is necessary, especially after large storm events. If the trench does not drain after 3 days, it usually means that the trench is clogged.

| Advantages of Infiltration Trenches |
|--|
| <ul style="list-style-type: none">• Preserve the natural water balance of the site• Are effective for small sites• Remove pollutants effectively |
| Disadvantages of Infiltration Trenches |
| <ul style="list-style-type: none">• Require high maintenance when sediment loads are heavy• Have short life span, especially if not maintained properly• May be expensive (cost of excavation and fill material) |

Porous Pavements/Concrete Grids and Modular Pavements

What Are They

Porous pavement, concrete grids, and modular pavements allow storm water to infiltrate so that the speed and amount of runoff from a site can be reduced.

Porous Pavement—Can be either asphalt or concrete. With porous asphalt pavement, runoff infiltrates through a porous asphalt layer into a stone "reservoir" layer. Storm water runoff filters through the stone reservoir into the underlying subsoil or drains into underground pipes through holes and is routed away. The bottom and sides of the stone reservoir are lined with filter fabric to prevent the movement of soils into the reservoir area.

Porous Concrete Pavement—Is made out of a special concrete mix that has a high number of open spaces between the particles and a coarse surface texture. These open spaces allow runoff to pass through the surface to lower levels. This type of pavement can be placed directly on graded soils. When a subbase is used for stability, 6 inches of sand is placed under the concrete mixture. Up to 6 inches of storm water can be held on the surface of the pavement and within the concrete.

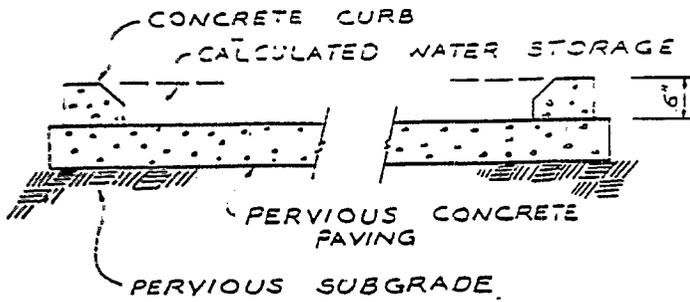
Concrete Grids and Modular Pavement—Are made out of precast concrete, poured-in-place concrete, brick, or granite. These types of pavements can also reduce the loading and concentration of pollutants in the runoff. Concrete grids and modular pavements are designed and/or constructed so that they have open spaces within the pavement through which storm water can infiltrate into the ground. These open spaces can be filled with gravel or sand or have vegetation growing out of them.

When and Where to Use Them

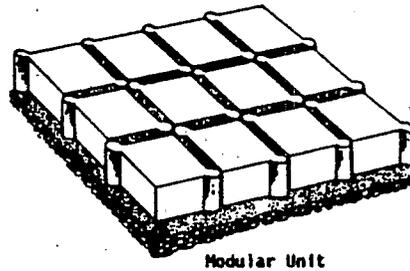
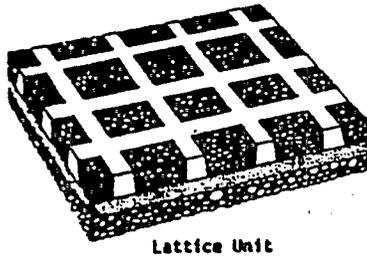
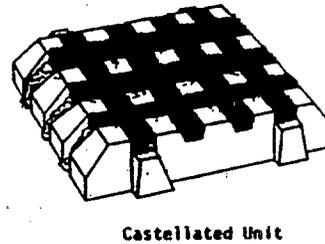
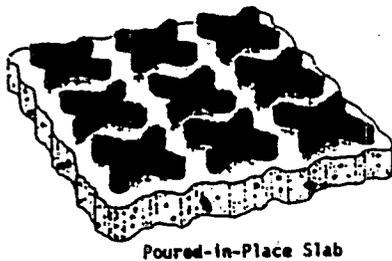
These structures are usually only suitable for low-volume parking areas (1/4 acre to 10 acres) (State of Maryland, 1983) and lightly used access roads. However, areas that are expected to get moderate or high volumes of traffic or heavy equipment can use conventional pavements (for the heavy traffic areas) that are sloped to drain to areas with the porous pavements. These pavements are not effective in drainage areas that receive runoff containing high levels of sediment.

The soil types over which concrete grids and modular pavement are to be placed should allow for rapid drainage through the pores in the pavement. These pavements are not recommended for sites with slopes steeper than 5 percent (MWCOG, 1987) or sites with high water tables, shallow bedrock, fill soils, or localized clay lenses, which are conditions that would limit the ability of the runoff to infiltrate into surface soils. For example, the water table and bedrock should be at least 3 feet below the bottom of the stone reservoir. Porous pavement will not operate well in windy areas where sediment will be deposited on the porous pavement.

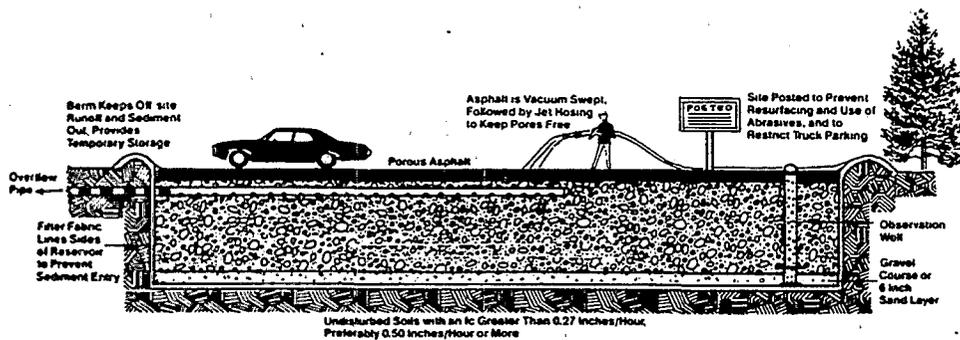
Construction of these pavements should be timed so that installation occurs on the site after other construction activities are finished and the site has been stabilized. Therefore, sediments are less likely to be tracked or carried on to the surface.



Detail of Pervious Concrete Pavement



Types of Grid and Modular Pavements



Cross Section of Porous Asphalt Pavement

FIGURE 4.35 POROUS PAVEMENTS, CONCRETE GRIDS, AND MODULAR PAVEMENTS (Modified from Commonwealth of Virginia, 1980; MWCOG, 1987; and Washington State, 1992)

What to Consider

Proper installation of these pavements requires a high level of construction expertise and workmanship. Only contractors who are familiar with the installation of these pavements should be used.

Designers of porous pavement areas should consider sediment and erosion control. Sediments must be kept away from the pavement area because they can clog the pores. Controls to consider for sediments include a diversion berm (i.e., earthen mound) around the edge of the pavement area to block the flow of runoff from certain drainages onto the pavement, or other filtering controls such as silt fences. De-icing salt mixtures, sands, or ash also may clog pores and should not be used for snow removal. Signs should be posted to prohibit these activities.

Since the infiltration of storm water runoff may contaminate ground water sources, these pavements are not suitable for areas close to drinking water wells (at least 100 feet away is recommended) (State of Maryland, 1983).

Maintenance of the surface is very important. For porous pavements, this includes vacuum sweeping at least four times per year followed by high-pressure hosing to reduce the chance of sediments clogging the pores of the top layer. Potholes and cracks can be filled with typical patching mixes unless more than 10 percent of the surface area needs repair. Spot clogging may be fixed by drilling half-inch holes through the porous pavement layer every few feet.

The pavement should be inspected several times the first few months after installation and then annually. Inspections after large storms are necessary to check for pools of water. These pools may indicate clogging. The condition of adjacent vegetated filter strips, silt fences, or diversion dikes should also be inspected.

Concrete grids and modular pavements should be designed in accordance with manufacturers' recommendations. Designers also need information on soils, depth to the water table, and storm water runoff quantity and quality.

Maintenance of concrete grids and modular pavements is similar to that of the porous pavements; however, turf maintenance such as mowing, fertilizing, and irrigation may be needed where vegetation is planted in the open spaces.

Advantages of Porous Pavements/Concrete Grids and Modular Pavements

- Provide erosion control by reducing the speed and quantity of the storm water runoff from the site
- Provide some treatment to the water by removing pollutants
- Reduce the need for curbing and storm sewer installation and expansion
- Improve road safety by providing a rougher surface
- Provide some recharge to local aquifers
- Are cost effective because they take the place of more expensive and complex treatment systems

Disadvantages of Porous Pavements/Concrete Grids and Modular Pavements

- Can be more expensive than typical pavements
- Are easily clogged with sediment and/or oil; however, pretreatment and proper maintenance will prevent this problem
- May cause ground water contamination
- Are not structurally suited for high-density traffic or heavy equipment
- Asphalt pavements may break down if gasoline is spilled on the surface
- Are less effective when the subsurface is frozen

APPENDIX A

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REFERENCES

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APPENDIX B

GLOSSARY

GLOSSARY

Aeration: A process which promotes biological degradation of organic matter. The process may be passive (as when waste is exposed to air) or active (as when a mixing or bubbling device introduces the air).

Backfill: Earth used to fill a trench or an excavation.

Baffles: Fin-like devices installed vertically on the inside walls of liquid waste transport vehicles that are used to reduce the movement of the waste inside the tank.

Berm: An earthen mound used to direct the flow of runoff around or through a structure.

Best Management Practice (BMP): Schedules of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent or reduce the pollution of waters of the United States. BMPs also include treatment requirements, operating procedures, and practices to control facility site runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage.

Biodegradable: The ability to break down or decompose under natural conditions and processes.

Boom: 1. A floating device used to contain oil on a body of water. 2. A piece of equipment used to apply pesticides from ground equipment such as a tractor or truck.

Buffer Strip or Zone: Strips of grass or other erosion-resistant vegetation between a waterway and an area of more intensive land use.

By-product: Material, other than the principal product, that is generated as a consequence of an industrial process.

Calibration: A check of the precision and accuracy of measuring equipment.

CERCLA: Comprehensive Environmental Response, Compensation, and Liability Act.

Chock: A block or wedge used to keep rolling vehicles in place.

Clay Lens: A naturally occurring, localized area of clay that acts as an impermeable layer to runoff infiltration.

Concrete aprons: A pad of nonerosive material designed to prevent scour holes developing at the outlet ends of culverts, outlet pipes, grade stabilization structures, and other water control devices.

Conduit: Any channel or pipe for transporting the flow of water.

Conveyance: Any natural or manmade channel or pipe in which concentrated water flows.

Corrosion: The dissolving and wearing away of metal caused by a chemical reaction such as between water and the pipes that the water contacts, chemicals touching a metal surface, or contact between two metals.

Culvert: A covered channel or a large-diameter pipe that directs water flow below the ground level.

CWA: Clean Water Act (formerly referred to as the Federal Water Pollution Control Act or Federal Water Pollution Control Act Amendments of 1972).

Denuded: Land stripped of vegetation such as grass, or land that has had vegetation worn down due to impacts from the elements or humans.

Dike: An embankment to confine or control water, often built along the banks of a river to prevent overflow of lowlands; a levee.

Director: The Regional Administrator or an authorized representative.

Discharge: A release or flow of storm water or other substance from a conveyance or storage container.

Drip Guard: A device used to prevent drips of fuel or corrosive or reactive chemicals from contacting other materials or areas.

Emission: Pollution discharged into the atmosphere from smokestacks, other vents, and surface areas of commercial or industrial facilities and from motor vehicle, locomotive, or aircraft exhausts.

Erosion: The wearing away of land surface by wind or water. Erosion occurs naturally from weather or runoff but can be intensified by land-clearing practices related to farming, residential or industrial development, road building, or timber-cutting.

Excavation: The process of removing earth, stone, or other materials.

Fertilizer: Materials such as nitrogen and phosphorus that provide nutrients for plants. Commercially sold fertilizers may contain other chemicals or may be in the form of processed sewage sludge.

Filter Fabric: Textile of relatively small mesh or pore size that is used to (a) allow water to pass through while keeping sediment out (permeable), or (b) prevent both runoff and sediment from passing through (impermeable).

Filter Strip: Usually long, relatively narrow area of undisturbed or planted vegetation used to retard or collect sediment for the protection of watercourses, reservoirs, or adjacent properties.

Flange: A rim extending from the end of a pipe; can be used as a connection to another pipe.

Flow Channel Liner: A covering or coating used on the inside surface of a flow channel to prevent the infiltration of water to the ground.

Flowmeter: A gauge that shows the speed of water moving through a conveyance.

General Permit: A permit issued under the NPDES program to cover a certain class or category of storm water discharges. These permits allow for a reduction in the administrative burden associated with permitting storm water discharges associated with industrial activities. For example, EPA is planning to issue two general permits: NPDES General Permits for Storm Water Discharges From Construction Activities that are classified as "Associated with Industrial Activity" and NPDES General Permits for Storm Water Discharges from Industrial Activities that are classified as "Associated with Industrial Activities." EPA is also encouraging delegated States which have an approved general permits program to issue general permits.

Grading: The cutting and/or filling of the land surface to a desired slope or elevation.

Hazardous Substance: 1. Any material that poses a threat to human health and/or the environment. Hazardous substances can be toxic, corrosive, ignitable, explosive, or chemically reactive. 2. Any substance named required by EPA to be reported if a designated quantity of the substance is spilled in the waters of the United States or if otherwise emitted into the environment.

Hazardous Waste: By-products of human activities that can pose a substantial or potential hazard to human health or the environment when improperly managed. Possesses at least one of four characteristics (ignitability, corrosivity, reactivity, or toxicity), or appears on special EPA lists.

Holding Pond: A pond or reservoir, usually made of earth, built to store polluted runoff for a limited time.

Illicit Connection: Any discharge to a municipal separate storm sewer that is not composed entirely of storm water except discharges authorized by an NPDES permit (other than the NPDES permit for discharges from the municipal separate storm sewer) and discharges resulting from fire fighting activities.

Infiltration: 1. The penetration of water through the ground surface into sub-surface soil or the penetration of water from the soil into sewer or other pipes through defective joints, connections, or manhole walls. 2. A land application technique where large volumes of wastewater are applied to land, allowed to penetrate the surface and percolate through the underlying soil.

Inlet: An entrance into a ditch, storm sewer, or other waterway.

Intermediates: A chemical compound formed during the making of a product.

Irrigation: Human application of water to agricultural or recreational land for watering purposes.

Jute: A plant fiber used to make rope, mulch, netting, or matting.

Lagoon: A shallow pond where sunlight, bacterial action, and oxygen work to purify wastewater.

Land Application Units: An area where wastes are applied onto or incorporated into the soil surface (excluding manure spreading operations) for treatment or disposal.

Land Treatment Units: An area of land where materials are temporarily located to receive treatment. Examples include: sludge lagoons, stabilization pond.

Landfills: An area of land or an excavation in which wastes are placed for permanent disposal, and which is not a land application unit, surface impoundment, injection well, or waste pile.

Large and Medium Municipal Separate Storm Sewer System: All municipal separate storm sewers that are either: (i) located in an incorporated place (city) with a population of 100,000 or more as determined by the latest Decennial Census by the Bureau of Census (these cities are listed in Appendices F and G of 40 CFR Part 122); or (ii) located in the counties with unincorporated urbanized populations of 100,000 or more, except municipal separate storm sewers that are located in the incorporated places, townships, or towns within such counties (these counties are listed in Appendices H and I of 40 CFR Part 122); or (iii) owned or operated by a municipality other than those described in paragraph (i) or (ii) and that are designated by the Director as part of the large or medium municipal separate storm sewer system.

Leaching: The process by which soluble constituents are dissolved in a solvent such as water and carried down through the soil.

Level Spreader: A device used to spread out storm water runoff uniformly over the ground surface as sheetflow (i.e., not through channels). The purpose of level spreaders are to prevent concentrated, erosive flows from occurring and to enhance infiltration.

Liming: Treating soil with lime to neutralize acidity levels.

Liner: 1. A relatively impermeable barrier designed to prevent leachate from leaking from a landfill. Liner materials include plastic and dense clay. 2. An insert or sleeve for sewer pipes to prevent leakage or infiltration.

Liquid Level Detector: A device that provides continuous measures of liquid levels in liquid storage areas or containers to prevent overflows.

Material Storage Areas: Onsite locations where raw materials, products, final products, by-products, or waste materials are stored.

Mulch: A natural or artificial layer of plant residue or other materials covering the land surface which conserves moisture, holds soil in place, aids in establishing plant cover, and minimizes temperature fluctuations.

Noncontact Cooling Water: Water used to cool machinery or other materials without directly contacting process chemicals or materials.

Notice of Intent (NOI): An application to notify the permitting authority of a facility's intention to be covered by a general permit; exempts a facility from having to submit an individual or group application.

NPDES: EPA's program to control the discharge of pollutants to waters of the United States. See the definition of "National Pollutant Discharge Elimination System" in 40 CFR 122.2 for further guidance.

NPDES Permit: An authorization, license, or equivalent control document issued by EPA or an approved State agency to implement the requirements of the NPDES program.

Oil and Grease Traps: Devices which collect oil and grease, removing them from water flows.

Oil Sheen: A thin, glistening layer of oil on water.

Oil/Water Separator: A device installed, usually at the entrance to a drain, which removes oil and grease from water flows entering the drain.

Organic Pollutants: Substances containing carbon which may cause pollution problems in receiving streams.

Organic Solvents: Liquid organic compounds capable of dissolving solids, gases, or liquids.

Outfall: The point, location, or structure where wastewater or drainage discharges from a sewer pipe, ditch, or other conveyance to a receiving body of water.

Permeability: The quality of a soil that enables water or air to move through it. Usually expressed in inches/hour or inches/day.

- Permit:** An authorization, license, or equivalent control document issued by EPA or an approved State agency to implement the requirements of an environmental regulation; e.g., a permit to operate a wastewater treatment plant or to operate a facility that may generate harmful emissions.
- Permit Issuing Authority (or Permitting Authority):** The State agency or EPA Regional office which issues environmental permits to regulated facilities.
- Plunge pool:** A basin used to slow flowing water, usually constructed to a design depth and shape. The pool may be protected from erosion by various lining materials.
- Pneumatic Transfer:** A system of hoses which uses the force of air or other gas to push material through; used to transfer solid or liquid materials from tank to tank.
- Point Source:** Any discernible, confined, and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged. This term does not include return flows from irrigated agriculture or agricultural storm water runoff.
- Pollutant:** Any dredged spoil, solid waste, incinerator residue, filter backwash, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials (except those regulated under the Atomic Energy Act of 1954, as amended (42 U.S.C. 2011 *et seq.*)), heat, wrecked or discharged equipment, rock, sand, cellar dirt, and industrial, municipal, and agricultural waste discharged into water. It does not mean:
- (i) Sewage from vessels; or
 - (ii) Water, gas, or other material which is injected into a well to facilitate production of oil or gas, or water derived in association with oil and gas production and disposed of in a well, if the well used either to facilitate production or for disposal purposes is approved by the authority of the State in which the well is located, and if the State determines that the injection or disposal will not result in the degradation of ground or surface water resources [Section 502(6) of the CWA].
- Radioactive materials covered by the Atomic Energy Act are those encompassed in its definition of source, byproduct, or special nuclear materials. Examples of materials not covered include radium and accelerator-produced isotopes. See Train v. Colorado Public Interest Research Group, Inc., 426 U.S. 1 (1976).
- Porous Pavement:** A human-made surface that will allow water to penetrate through and percolate into soil (as in porous asphalt pavement or concrete). Porous asphalt pavement is comprised of irregular shaped crush rock precoated with asphalt binder. Water seeps through into lower layers of gravel for temporary storage, then filters naturally into the soil.
- Precipitation:** Any form of rain or snow.
- Preventative Maintenance Program:** A schedule of inspections and testing at regular intervals intended to prevent equipment failures and deterioration.
- Process Wastewater:** Water that comes into direct contact with or results from the production or use of any raw material, intermediate product, finished product, by-product, waste product, or wastewater.
- PVC (Polyvinyl Chloride):** A plastic used in pipes because of its strength; does not dissolve in most organic solvents.

Raw Material: Any product or material that is converted into another material by processing or manufacturing.

RCRA: Resource Conservation and Recovery Act.

Recycle: The process of minimizing the generation of waste by recovering usable products that might otherwise become waste. Examples are the recycling of aluminum cans, wastepaper, and bottles.

Reportable Quantity (RQ): The quantity of a hazardous substance or oil that triggers reporting requirements under CERCLA or the Clean Water Act. If a substance is released in amounts exceeding its RQ, the release must be reported to the National Response Center, the State Emergency Response Commission, and community emergency coordinators for areas likely to be affected (see Appendix I for a list of RQs).

Residual: Amount of pollutant remaining in the environment after a natural or technological process has taken place, e.g., the sludge remaining after initial wastewater treatment, or particulates remaining in air after the air passes through a scrubbing or other pollutant removal process.

Retention: The holding of runoff in a basin without release except by means of evaporation, infiltration, or emergency bypass.

Retrofit: The modification of storm water management systems in developed areas through the construction of wet ponds, infiltration systems, wetland plantings, stream bank stabilization, and other BMP techniques for improving water quality. A retrofit can consist of the construction of a new BMP in the developed area, the enhancement of an older storm water management structure, or a combination of improvement and new construction.

Rill Erosion: The formation of numerous, closely spread streamlets due to uneven removal of surface soils by storm water or other water.

Riparian Habitat: Areas adjacent to rivers and streams that have a high density, diversity, and productivity of plant and animal species relative to nearby uplands.

Runon: Storm water surface flow or other surface flow which enters property other than that where it originated.

Runoff: That part of precipitation, snow melt, or irrigation water that runs off the land into streams or other surface water. It can carry pollutants from the air and land into the receiving waters.

Sanitary Sewer: A system of underground pipes that carries sanitary waste or process wastewater to a treatment plant.

Sanitary Waste: Domestic sewage.

SARA: Superfund Amendments and Reauthorization Act.

Scour: The clearing and digging action of flowing water, especially the downward erosion caused by stream water in sweeping away mud and silt from the stream bed and outside bank of a curved channel.

Sealed Gate: A device used to control the flow of liquid materials through a valve.

Secondary Containment: Structures, usually dikes or berms, surrounding tanks or other storage containers and designed to catch spilled material from the storage containers.

Section 313 Water Priority Chemical: A chemical or chemical categories which are: (1) are listed at 40 CFR 372.65 pursuant to Section 313 of the Emergency Planning and Community Right-to-Know Act (EPCRA) [also known as Title III of the Superfund Amendments and Reauthorization Act (SARA) of 1986]; (2) are present at or above threshold levels at a facility subject to EPCRA Section 313 reporting requirements; and (3) that meet at least one of the following criteria: (i) are listed in Appendix D of 40 CFR Part 122 on either Table II (organic priority pollutants), Table III (certain metals, cyanides, and phenols), or Table V (certain toxic pollutants and hazardous substances); (ii) are listed as a hazardous substance pursuant to Section 311(b)(2)(A) of the CWA at 40 CFR 116.4; or (iii) are pollutants for which EPA has published acute or chronic water quality criteria. See Addendum B of this permit. (List is included as Appendix I.)

Sediment Trap: A device for removing sediment from water flows; usually installed at outfall points.

Sedimentation: The process of depositing soil particles, clays, sands, or other sediments that were picked up by flowing water.

Sediments: Soil, sand, and minerals washed from land into water, usually after rain. They pile up in reservoirs, rivers, and harbors, destroying fish-nesting areas and holes of water animals and cloud the water so that needed sunlight might not reach aquatic plants. Careless farming, mining, and building activities will expose sediment materials, allowing them to be washed off the land after rainfalls.

Sheet Erosion: Erosion of thin layers of surface materials by continuous sheets of running water.

Sheetflow: Runoff which flows over the ground surface as a thin, even layer, not concentrated in a channel.

Shelf Life: The time for which chemicals and other materials can be stored before becoming unusable due to age or deterioration.

Significant Materials: Include, but are not limited to: raw materials; fuels; materials such as solvents, detergents and plastic pellets; finished materials such as metallic products; raw materials used in food processing or production; hazardous substances designated under section 101(14) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA); any chemical the facility is required to report pursuant to section 313 of Title III of the Superfund Amendments and Reauthorization Act (SARA); fertilizers; pesticides; and waste products such as ashes, slag, and sludge that have a potential to be released with storm water discharges [122.26(b)(12)].

Significant Spills: Includes, but is not limited to: releases of oil or hazardous substances in excess of reportable quantities under Section 311 of the CWA (see 40 CFR 110.10 and CFR 117.21) or Section 102 of CERCLA (see 40 CFR 302.4).

Slag: Non-metal containing waste leftover from the smelting and refining of metals.

Slide Gate: A device used to control the flow of water through storm water conveyances.

Sloughing: The movement of unstabilized soil layers down a slope due to excess water in the soils.

Sludge: A semi-solid residue from any of a number of air or water treatment processes. Sludge can be a hazardous waste.

Soil: The unconsolidated mineral and organic material on the immediate surface of the earth that serves as a natural medium for the growth of plants.

Solids Dewatering: A process for removing excess water from solids to lessen the overall weight of the wastes.

Source Control: A practice or structural measure to prevent pollutants from entering storm water runoff or other environmental media.

Spent Solvent: A liquid solution that has been used and is no longer capable of dissolving solids, gases, or liquids.

Spill Guard: A device used to prevent spills of liquid materials from storage containers.

Spill Prevention Control and Countermeasures Plan (SPCC): Plan consisting of structures, such as curbing, and action plans to prevent and respond to spills of hazardous substances as defined in the Clean Water Act.

Stopcock Valve: A small valve for stopping or controlling the flow of water or other liquid through a pipe.

Storm Drain: A slotted opening leading to an underground pipe or an open ditch for carrying surface runoff.

Storm Water: Runoff from a storm event, snow melt runoff, and surface runoff and drainage.

Storm Water Discharge Associated with Industrial Activity: The discharge from any conveyance which is used for collecting and conveying storm water and which is directly related to manufacturing, processing or raw materials storage areas at an industrial plant. The term does not include discharges from facilities or activities excluded from the NPDES program under 40 CFR Part 122. For the categories of industries identified in subparagraphs (i) through (x) of this subsection, the term includes, but is not limited to, storm water discharges from industrial plant yards; immediate access roads and rail lines used or traveled by carriers of raw materials, manufactured products, waste material, or by-products used or created by the facility; material handling sites; refuse sites; sites used for the application or disposal of process waste waters (as defined at 40 CFR 401); sites used for the storage and maintenance of material handling equipment; sites used for residual treatment, storage, or disposal; shipping and receiving areas; manufacturing buildings; storage areas (including tank farms) for raw materials, and intermediate and finished products; and areas where industrial activity has taken place in the past and significant materials remain and are exposed to storm water. For the categories of industries identified in subparagraph (xi), the term includes only storm water discharges from all the areas (except access roads and rail lines) that are listed in the previous sentence where material handling equipment or activities, raw materials, intermediate products, final products, waste material, by-products, or industrial machinery are exposed to storm water. For the purposes of this paragraph, material handling activities include the: storage, loading and unloading, transportation, or conveyance of any raw material, intermediate product, finished product, by-product or waste product. The term excludes areas located on plant lands separate from the plant's industrial activities, such as office buildings and accompanying parking lots as long as the drainage from the excluded areas is not mixed with storm water drained from the above described areas. Industrial facilities (including industrial facilities that are Federally, State, or municipally owned or operated that meet the description of the facilities listed in this paragraph (i)-(xi) include those facilities designated under the provision of 122.26(a)(1)(v). The following categories of facilities are considered to be engaging in "industrial activity" for purposes of this subsection:

- (i) Facilities subject to storm water effluent limitations guidelines, new source performance standards, or toxic pollutant effluent standards under 40 CFR Subchapter N (except facilities with toxic pollutant effluent standards which are excepted under category (xi) of this paragraph);
- (ii) Facilities classified as Standard Industrial Classifications 24 (except 2434), 26 (except 265 and 267), 28 (except 283 and 285) 29, 311, 32 (except 323), 33, 3441, 372;
- (iii) Facilities classified as Standard Industrial Classifications 10 through 14 (mineral industry) including active or inactive mining operations (except for areas of coal mining operations no longer meeting the definition of a reclamation area under 40 CFR 434.11(I) because the performance bond issued to the facility by the appropriate SMCRA authority has been released, or except for areas of non-coal mining operations which have been released from applicable State or Federal reclamation requirements after December 17, 1990 and oil and gas exploration, production, processing, or treatment operations, or transmission facilities that discharge storm water contaminated by contact with or that has come into contact with, any overburden, raw material, intermediate products, finished products, byproducts or waste products located on the site of such operations; (inactive mining operations are mining sites that are not being actively mined, but which have an identifiable owner/operator; inactive mining sites do not include sites where mining claims are being maintained prior to disturbances associated with the extraction, beneficiation, or processing of mined materials, nor sites where minimal activities are undertaken for the sole purpose of maintaining mining claim);
- (iv) Hazardous waste treatment, storage, or disposal facilities, including those that are operating under interim status or a permit under Subtitle C of RCRA;
- (v) Landfills, land application sites, and open dumps that receive or have received any industrial wastes (waste that is received from any of the facilities described under this subsection) including those that are subject to regulation under Subtitle D of RCRA;
- (vi) Facilities involved in the recycling of materials, including metal scrapyards, battery reclaimers, salvage yards, and automobiles junkyards, including but limited to those classified as Standard Industrial Classification 5015 and 5093;
- (vii) Steam electric power generating facilities, including coal handling sites;
- (viii) Transportation facilities classified as Standard Industrial Classifications 40, 41, 42 (except 4221-25), 43, 44, 45, and 5171 which have vehicle maintenance shops, equipment cleaning operations, or airport deicing operations. Only those portions of the facility that are either involved in vehicle maintenance (including vehicle rehabilitation, mechanical repairs, painting, fueling, and lubrication), equipment cleaning operations, airport deicing operations, or which are otherwise identified under paragraphs (i)-(vii) or (ix)-(xi) of this subsection are associated with industrial activity;
- (ix) Treatment works treating domestic sewage or any other sewage sludge or wastewater treatment device or system, used in the storage treatment, recycling, and reclamation of municipal or domestic sewage, including land dedicated to the disposal of sewage sludge that are located within the confines of the facility, with a design flow of 1.0 mgd or more, or required to have an approved pretreatment program under 40 CFR 403. Not included are farm lands, domestic gardens or lands used for sludge management where sludge is beneficially reused and which are not physically located in the confines of the facility, or areas that are in compliance with Section 405 of the CWA;
- (x) Construction activity including clearing, grading and excavation activities except: operations that result in the disturbance of less than five acres of total land area which are not part of a larger common plan of development or sale;
- (xi) Facilities under Standard Industrial Classification 20, 21, 22, 23, 2434, 25, 265, 267, 27, 283, 285, 30, 31 (except 311), 323, 34 (except 3441), 35, 36, 37 (except 373), 38, 39, 4221-25, (and which are not otherwise included within categories (ii)-(x));

Note: The Transportation Act of 1991 provides an exemption from storm water permitting requirements for certain facilities owned or operated by municipalities with a population of less than 100,000. Such municipalities must submit storm water

discharge permit applications for only airports, power plants, and uncontrolled sanitary landfills that they own or operate, unless a permit is otherwise required by the permitting authority.

Subsoil: The bed or stratum of earth lying below the surface soil.

Sump: A pit or tank that catches liquid runoff for drainage or disposal.

Surface Impoundment: Treatment, storage, or disposal of liquid wastes in ponds.

Surface Water: All water naturally open to the atmosphere (rivers, lakes, reservoirs, streams, wetlands impoundments, seas, estuaries, etc.); also refers to springs, wells, or other collectors which are directly influenced by surface water.

Swale: An elongated depression in the land surface that is at least seasonally wet, is usually heavily vegetated, and is normally without flowing water. Swales direct storm water flows into primary drainage channels and allow some of the storm water to infiltrate into the ground surface.

Tarp: A sheet of waterproof canvas or other material used to cover and protect materials, equipment, or vehicles.

Topography: The physical features of a surface area including relative elevations and the position of natural and human-made features.

Toxic Pollutants: Any pollutant listed as toxic under Section 501(a)(1) or, in the case of "sludge use or disposal practices," any pollutant identified in regulations implementing Section 405(d) of the CWA. Please refer to 40 CFR Part 122 Appendix D.

Treatment: The act of applying a procedure or chemicals to a substance to remove undesirable pollutants.

Tributary: A river or stream that flows into a larger river or stream.

Underground Storage Tanks (USTs): Storage tanks with at least 10 percent or more of its storage capacity underground (the complete regulatory definition is at 40 CFR Part 280.12).

Waste: Unwanted materials left over from a manufacturing or other process.

Waste Pile: Any noncontainerized accumulation of solid, nonflowing waste that is used for treatment or storage.

Water Table: The depth or level below which the ground is saturated with water.

Waters of the United States:

"(a) All waters, which are currently used, were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters which are subject to the ebb and flow of the tide;

(b) All interstate waters, including interstate "wetlands;"

(c) All other waters such as intrastate lakes, rivers, streams (including intermittent streams), mudflats, sandflats, "wetlands," sloughs, prairie potholes, wet meadows, playa lakes, or natural ponds, the use, degradation, or destruction of which would affect or could affect interstate or foreign commerce including any such waters:

(1) Which are or could be used by interstate or foreign travelers for recreational or other purposes;

- (2) From which fish or shellfish are or could be taken and sold in interstate or foreign commerce; or
- (3) Which are used or could be used for industrial purposes by industries in interstate commerce;
- (d) All impoundments of waters otherwise defined as waters of the United States under this definition;
- (e) Tributaries of waters identified in paragraphs (a) through (d) of this definition;
- (f) The territorial sea; and
- (g) "Wetlands" adjacent to waters (other than waters that are themselves wetlands) identified in paragraphs (a) through (f) of this definition.

Waste treatment systems, including treatment ponds or lagoons designed to meet the requirements of CWA (other than cooling ponds as defined in 40 CFR 423.11(m) which also meet the criteria of this definition) are not waters of the United States. This exclusion applies only to manmade bodies of water which neither were originally created in waters of the United States (such as disposal area in wetlands) nor resulted from the impoundment of waters of the United States.

Waterway: A channel for the passage or flow of water.

Wet Well: A chamber used to collect water or other liquid and to which a pump is attached.

Wetlands: An area that is regularly saturated by surface or ground water and subsequently is characterized by a prevalence of vegetation that is adapted for life in saturated soil conditions. Examples include: swamps, bogs, fens, marshes, and estuaries.

Wind Break: Any device designed to block wind flow and intended for protection against any ill effects of wind.

APPENDIX C
MODEL STORM WATER POLLUTION PREVENTION PLAN

Double Scoop Ice Cream Company

**40 Wonka Drive
Anytown, OK 12345**

December 1992

| Storm Water Pollution Prevention Plan | |
|--|--|
| Emergency Contact: Cheryl Glenn | Work Phone: (101) 555-1234 |
| Title: Plant Manager | Emergency Phone: (101) 555-6929 |
| Secondary Contact: Rachel Meyers | Work Phone: (101) 555-3923 |
| Title: Engineering Supervisor | Emergency Phone: (101) 555-6789 |
| Type of Manufacturer: Ice Cream Manufacturer | |
| Operating Schedule: 8:00 a.m. - 11:30 p.m. | |
| Number of Employees: The plant has 21 employees, including part time staff. Shifts overlap all day. | |
| Average Wastewater Discharge: 5,000 gallons per week | |
| NPDES Permit Number: OK1234567 | |

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POLLUTION PREVENTION TEAM

MEMBER ROSTER

Worksheet #1

Completed by: Cheryl Glenn

Title: Plant Manager

Date: December 12, 1992

Leader: Cheryl Glenn

Title: Plant Manager

Office Phone: (101) 555-1234

Responsibilities: Signatory authority; coordinate all stages of plan development and implementation; coordinate employee training program; keep all records and ensure reports are submitted.

Members:

(1) Stephen Michaels

Title: Production Supervisor

Office Phone: (101) 555-3923

Responsibilities: Note any process changes; help conduct inspections.

(2) Rachel Meyers

Title: Engineering Dept. Supervisor

Office Phone: (101) 555-5890

Responsibilities: Responsible for implementing the Preventive Maintenance program; oversee inspections.

(3) Isaac Feldman

Title: Maintenance Dept. Supervisor

Office Phone: (101) 555-0482

Responsibilities: Mr. Feldman is the spill response coordinator; Oversees "good housekeeping."

(4) Group Activities

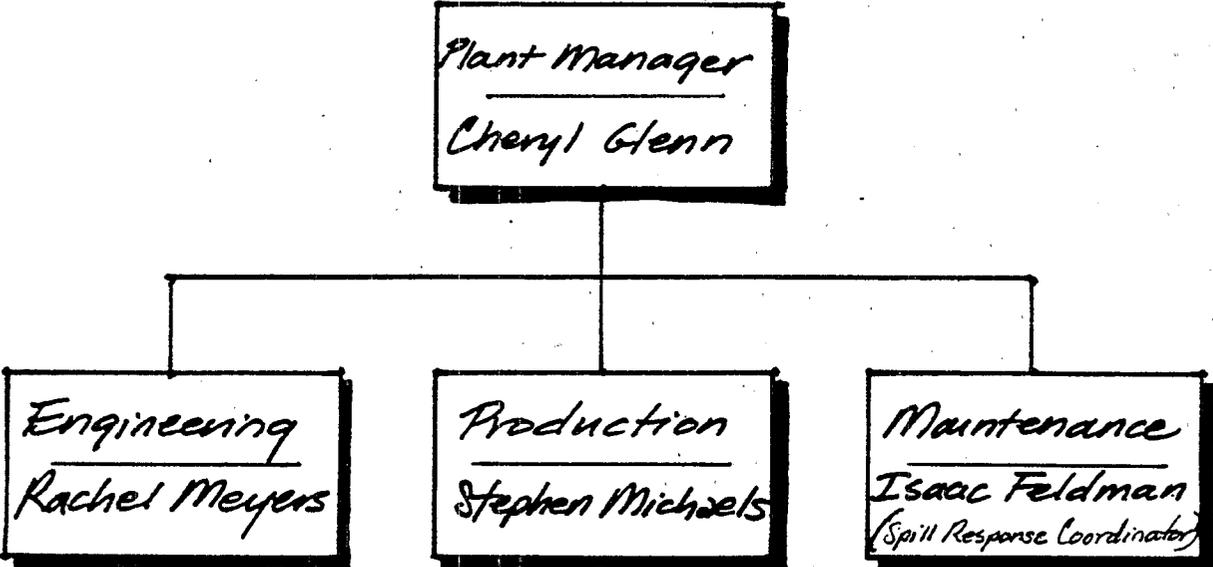
Title: _____

Office Phone: _____

Responsibilities: Developing the plan elements, choosing storm water management options.

(6-3)

Pollution Prevention Team
Organization Chart



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Double Scoop Ice Cream Company

**- Storm Water Pollution Prevention Plan
Comparison with SPCC Plan**

Double Scoop Ice Cream Plant has an SPCC plan in operation for its aboveground fuel storage tank. Overlaps are noted below:

- Isaac Feldman is the SPCC Coordinator and reports directly to Cheryl Glenn. He will be the Storm Water Spill Prevention and Response Coordinator.
- A complete description of potential for oil to contaminate storm water discharges including quantity of oil that could be discharged.
- Curbing around aboveground fuel storage tank identified on site map.
- Expanded SPCC schedules and procedures to include Storm Water Pollution Prevention Plan requirements.
- Incorporated SPCC plan training into storm water training programs on spill prevention and response.
- Relevant portions of the SPCC plan will be included in this plan.

(C-5)

DEVELOPING A SITE MAP

Worksheet #2

Completed by:

Title:

Date:

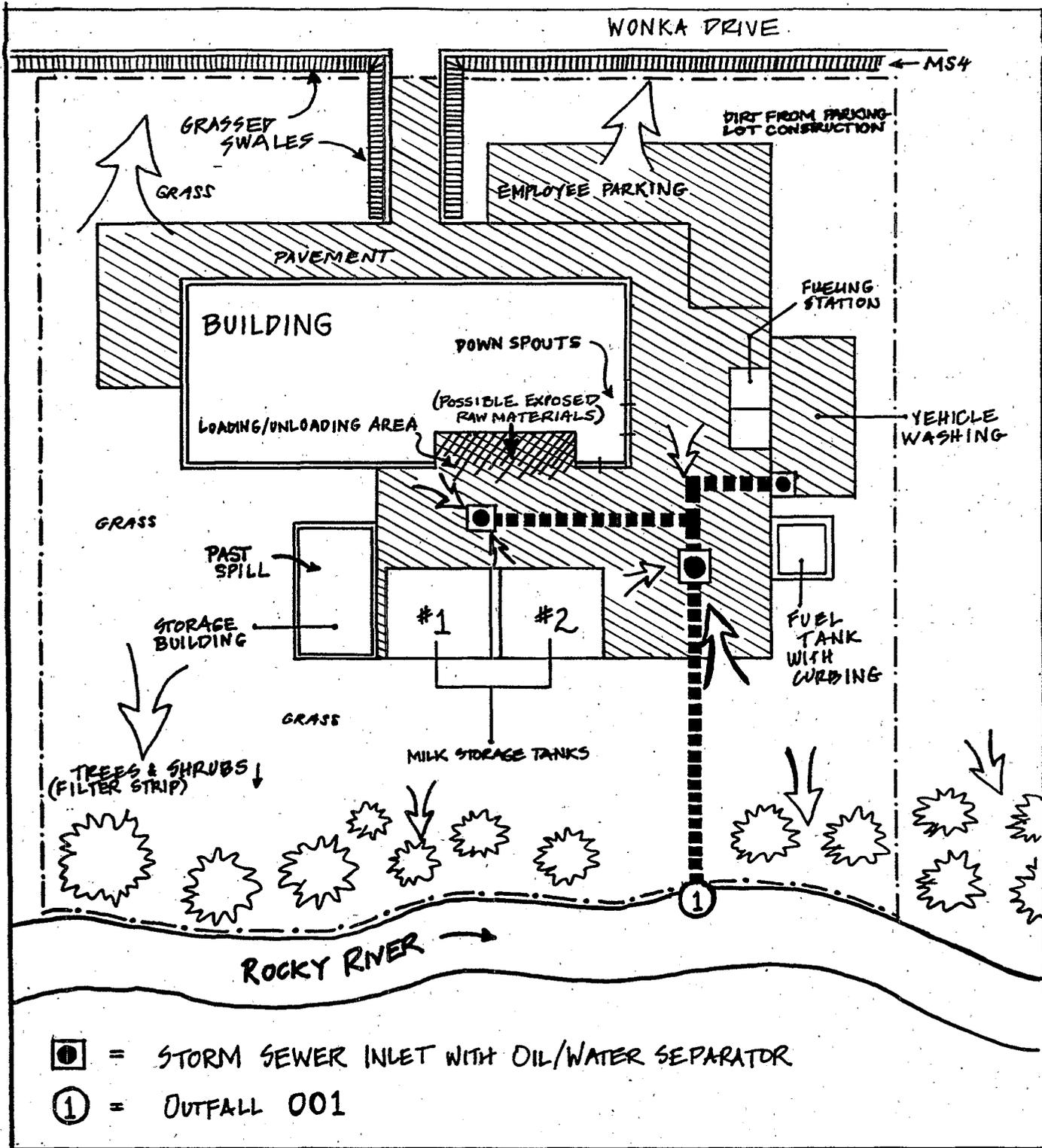
Cheryl Glenn
Plant Manager
December 12, 1997

Instructions: Draw a map of your site including a footprint of all buildings, structures, paved areas, and parking lots. The information below describes additional elements required by EPA's General Permit (see example maps in Figures 2.3 and 2.4).

EPA's General Permit requires that you indicate the following features on your site map:

- All outfalls and storm water discharges
- Drainage areas of each storm water outfall
- Structural storm water pollution control measures, such as:
 - Flow diversion structures
 - Retention/detention ponds
 - Vegetative swales
 - Sediment traps
- Name of receiving waters (or if through a Municipal Separate Storm Sewer System)
- Locations of exposed significant materials (see Section 2.2.2)
- Locations of past spills and leaks (see Section 2.2.3)
- Locations of high-risk, waste-generating areas and activities common on industrial sites such as:
 - Fueling stations
 - Vehicle/equipment washing and maintenance areas
 - Area for unloading/loading materials
 - Above-ground tanks for liquid storage
 - Industrial waste management areas (landfills, waste piles, treatment plants, disposal areas)
 - Outside storage areas for raw materials, by-products, and finished products
 - Outside manufacturing areas
 - Other areas of concern (specify: _____)

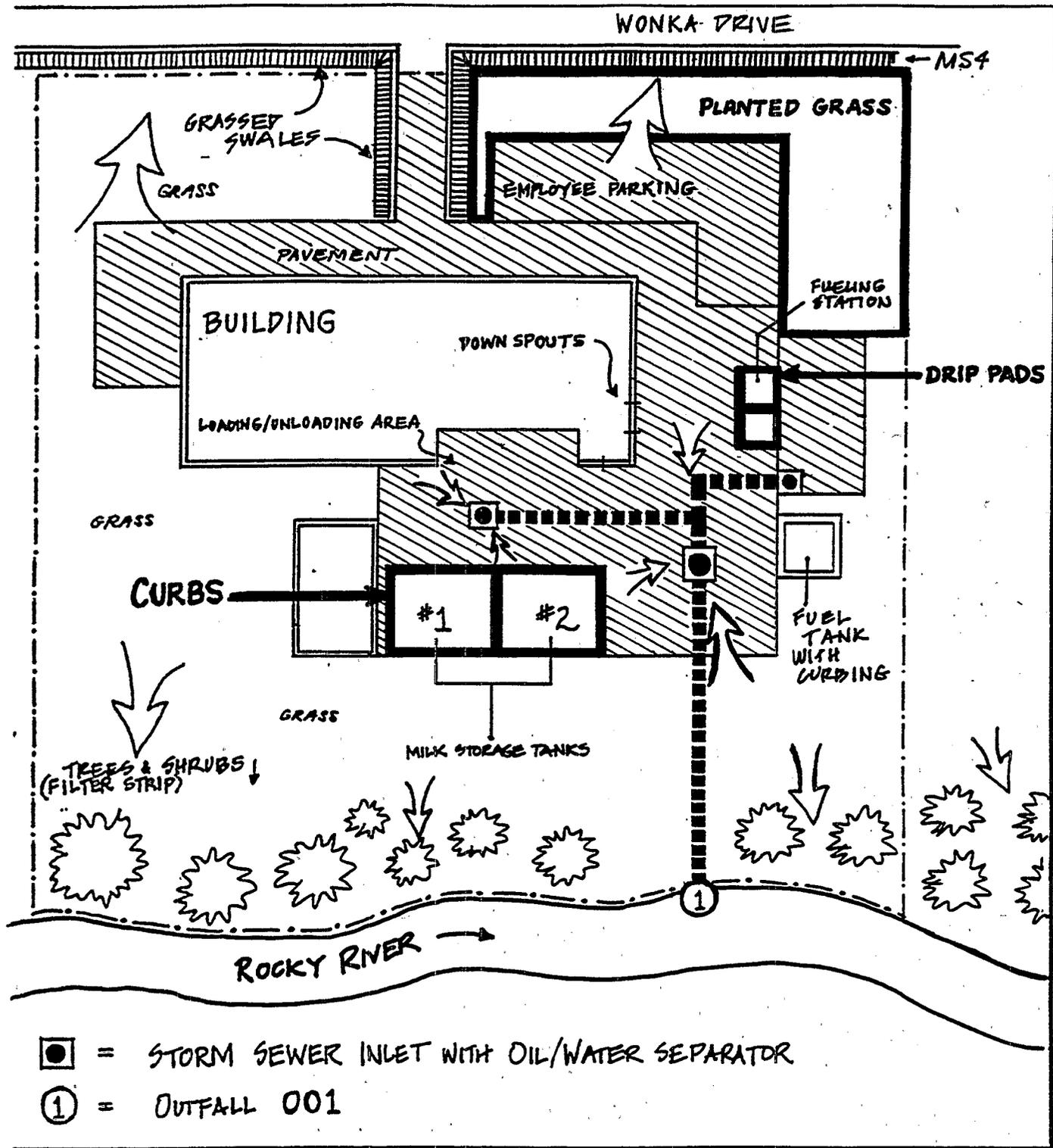
C-7



DOUBLE SCOOP ICE CREAM COMPANY

**PRE-BMP SITE MAP
MARCH 1, 1993**

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DOUBLE SCOOP ICE CREAM COMPANY

**POST-BMP SITE MAP
MARCH 1, 1993**

C-10

MATERIAL INVENTORY

Worksheet #3

Completed by: Cheryl Glenn

Title: Plant Manager

Date: December 12, 1992

Instructions: List all materials used, stored, or produced onsite. Assess and evaluate these materials for their potential to contribute pollutants to storm water runoff. Also complete Worksheet 3A if the material has been exposed during the last three years.

| Material | Purpose/Location | Quantity (units) | | | Quantity Exposed in Last 3 Years | Likelihood of contact with storm water. If yes, describe reason. | Past Significant Spill or Leak | |
|--|---|------------------|----------------|--------------|----------------------------------|---|--------------------------------|----|
| | | Used | Produced | Stored | | | Yes | No |
| Butter fat Milk Solids Whey solids | truck unloading area during transfer to liquid ingredient storage and milk vat storage. | 72,600 gal/wk | - | 2,000 gal/wk | NO | Truck loading area outside and possible exposure with ruptured tanks. | | ✓ |
| Corn Syrup Liquid sugar | Truck unloading area during transfer to sweetener storage. | 7,100 gal/wk | - | - | yes | Truck loading area outside with possible exposure as a result of leaking tanks. | ✓ | |
| Ice cream | Inside freezers for final product shipping. | | 35-40,000 lbs. | | NO | NO | | ✓ |
| <u>Cleansers:</u> | | | | | | | | |
| Granular Chlorshire-0 | Dry cleansers in dry storage area (indoors) | 400 lb/wk | - | - | NO | Yes. Possible storage exposure during transfer to dry storage area. | | ✓ |
| H.D.C. - 3R Power Spray-R | | | | | | | | |

(C-11)

MATERIAL INVENTORY

Page 2

Worksheet #3

Completed by: Cheryl Glenn

Title: Plant Manager

Date: December 12, 1992

Instructions: List all materials used, stored, or produced onsite. Assess and evaluate these materials for their potential to contribute pollutants to storm water runoff. Also complete Worksheet 3A if the material has been exposed during the last three years.

| Material | Purpose/Location | Quantity (units) | | | Quantity Exposed in Last 3 Years | Likelihood of contact with storm water. If yes, describe reason. | Past Significant Spill or Leak | |
|-------------------|------------------------------|------------------|----------|--------|----------------------------------|---|--------------------------------|----|
| | | Used | Produced | Stored | | | Yes | No |
| <u>Cleanders:</u> | | | | | | | | |
| liquid | Cleanders are stored outside | 100 gal/wk | — | — | NO | Yes-if material tanks stored outside. | | ✓ |
| M.R.S.-200-0 | under cover | | | | | | | |
| Acidize - 0 | | | | | | | | |
| Microsan | | | | | | | | |
| <u>Fuels:</u> | | | | | | | | |
| gasoline | above ground | 250 gal/wk | — | — | NO | Yes - possible exposure in the event of defective tanks or transfer of materials from tanks to containers | | ✓ |
| motor oil | 750 gallon storage tank | 20 gal/wk | — | — | NO | | | ✓ |
| soaps | | 40 gal/wk | — | — | NO | | | ✓ |
| detergents | | | | | | | | |

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NWMMAR117486

DESCRIPTION OF EXPOSED SIGNIFICANT MATERIAL

Worksheet #3A

Completed by: Cheryl Glenn

Title: Plant Manager

Date: December 12, 1992

Instructions: Based on your material inventory, describe the significant materials that were exposed to storm water during the past three years and/or are currently exposed. For the definition of "significant materials" see Appendix B of the manual.

| Description of Exposed Significant Material | Period of Exposure | Quantity Exposed (units) | Location (as indicated on the site map) | Method of Storage or Disposal (e.g., pile, drum, tank) | Description of Material Management Practice (e.g., pile covered, drum sealed) |
|---|--------------------|--------------------------|---|--|--|
| liquid sugar | 1/21/92 | 10 gal. | storage building Tank #2 | 50 gal. tanks (2) | Leak was contained and mopped up. Remainder of liquid sugar transferred to tank that did not have a leaky valve. |
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LIST OF SIGNIFICANT SPILLS AND LEAKS

Worksheet #4

Completed by: Cheryl Glenn

Title: Plant Manager

Date: December 12, 1992

Directions: Record below all significant spills and significant leaks of toxic or hazardous pollutants that have occurred at the facility in the three years prior to the effective date of the permit.

Definitions: Significant spills include, but are not limited to, releases of oil or hazardous substances in excess of reportable quantities.

| 1st Year Prior | | | | | | | | | | |
|--------------------------|-------|------|--|------------------|----------|------------------|-------------|--|--|---|
| Date (month/day/year) | Spill | Leak | Location (as indicated on site map) | Description | | | | Response Procedure | | Preventive Measures Taken |
| | | | | Type of Material | Quantity | Source, If Known | Reason | Amount of Material Recovered | Material No Longer Exposed to Storm Water (True/False) | |
| | | | | N | O | N | E | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| 2nd Year Prior | | | | | | | | | | |
| Date (month/day/year) | Spill | Leak | Location (as indicated on site map) | Description | | | | Response Procedure | | Preventive Measures Taken |
| | | | | Type of Material | Quantity | Source, If Known | Reason | Amount of Material Recovered | Material No Longer Exposed to Storm Water (True/False) | |
| 1/21/91 | | ✓ | STORAGE BLDG. | LIQUID SUGAR | 10 ga. | Tank #2 | leaky valve | contained and mopped spill - transferred | True | installing curbing around tank - to be completed - 2/93 |
| | | | | | | | | | | |
| | | | | | | | | | | |
| 3rd Year Prior | | | | | | | | | | |
| Date (month/day/year) | Spill | Leak | Location (as indicated on site map) | Description | | | | Response Procedure | | Preventive Measures Taken |
| | | | | Type of Material | Quantity | Source, If Known | Reason | Amount of Material Recovered | Material No Longer Exposed to Storm Water (True/False) | |
| | | | | N | O | N | E | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |

C-14

**NON-STORM WATER DISCHARGE
ASSESSMENT AND CERTIFICATION**

Worksheet #5

Completed by:

Rachel Meyers

Title:

Engineering Department Supervisor

Date:

3/1/93

| Date of Test or Evaluation | Outfall Directly Observed During the Test (identify as indicated on the site map) | Method Used to Test or Evaluate Discharge | Describe Results from Test for the Presence of Non-Storm Water Discharge | Identify Potential Significant Sources | Name of Person Who Conducted the Test or Evaluation |
|--|---|---|--|--|---|
| <i>12/24/92</i> | <i>001</i> | <i>visual inspection</i> | <i>No discharge observed</i> | | <i>R. Meyers and S. Goodhope</i> |
| <i>1/19/93</i> | <i>001</i> | <i>visual inspection</i> | <i>significant flow; oil</i> | <i>vehicle wash ongoing at time</i> | <i>R. Meyers and S. Goodhope</i> |
| <i>2/5/93</i> | <i>001</i> | <i>visual inspection</i> | <i>small amount of discharge observed; clear</i> | <i>suspected to be delayed storm water discharge from storm that occurred 2/1/93</i> | <i>R. Meyers and S. Goodhope</i> |
| | | | | | |
| <i>* See details in attached field notebook.</i> | | | | | |

CERTIFICATION

I, *Cheryl Glenn* (responsible corporate official), certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

A. Name & Official Title (type or print)

Cheryl Glenn

B. Area Code and Telephone No.

(101) 535-1239

C. Signature

Cheryl Glenn

D. Date Signed

3/2/93

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FIELD NOTEBOOK

for non-storm water discharge inspections

INSPECTION TEAM:

R. Meyers

S. Goodhope

Completed by: Rachel Meyers

Date: 12/24/92

Time: 10:50 am

Time since last rain: 42 hours

Quantity of last rain: 0.12 inches

Flow observed: NO

SIGNATURE: Rachel Meyers

Completed by: Rachel Meyers

Date: 1/19/93

Time: 3:20 pm

Time since last rain: 5 days

Quantity of last rain: 0.5 inches

Flow observed: YES

DESCRIPTION: No odor; clear color
(soap suds); oily sheen; some
sediment.

Temperature: cold (37.5°F)

Volume: collected ten gallons/minute in buckets

Comments: Vehicle wash ongoing at time of inspection.
This was the source of the flow.

SIGNATURE: Rachel Meyers

Completed by: Rachel Meyers

Date: 2/5/93

Time: 12:15 pm.

Time since last rain: 96 hours

Quantity of last rain: 2.5 inches

Flow observed: YES

DESCRIPTION: No odor; clear; some sediments;
few small pieces of paper (trash)

Temperature: cold (42.3°F)

Volume: Collected one gallon in 5 minutes.

Comments: We suspect that the flow was left over from
storm that occurred on 2/1/93 (4 days ago)

SIGNATURE: Rachel Meyers

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Double Scoop Ice Cream Company

Site Assessment Inspection

February 10, 1993

Evaluate the site for pollutants.

There are five areas where material handling and storage activities take place.

- The storage building contains tanks of corn syrup, liquid sugar, and the granular cleansers. The tanks were examined for possible leaks. We found that the valve on the liquid sugar tank #2 was faulty and had leaked approximately 10 gallons of liquid sugar. Although this leak occurred on 1/21/92, the faulty valve was not discovered until now. All other tanks are secure. Areas around the tanks were swept clean to determine if leaks or spills were prevalent.
- The milk storage tanks were then examined for leaks or exposure. Upon closer examination, it was found that the number 1 tank was leaking a small amount of milk to the drainage system. This leak may be the reason for the high concentration of biochemical oxygen demand found in the sample taken from the storm water discharge. The tank was temporarily fixed to ensure that no further contamination would result. A replacement tank was ordered on February 6, 1993, and was expected to arrive within 5 business days. The milk storage tanks shall be examined on a daily basis to further prevent possible exposure to the storm water collection system and receiving stream.
- We inspected the fueling station to see if there were any leaks. The general area surrounding the fueling station was clean but we observed that gasoline and motor oil falls during fueling. In accordance with standard operating conditions, facility personnel hose down the area during vehicle washing and the drain is connected to the storm sewer. We detected this connection on 1/19/93 during one of the non-storm water discharge assessment visual inspections. Since this discharge is not allowed under our general permit, we are in the process of submitting a separate permit application specifically for the discharge of vehicle wash water.
- We examined the fueling station which is adjacent to the vehicle washing area. Vehicle washing cleaners are used here and any empty or open containers were removed from the area.

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- We next looked at the loading and unloading docks where raw materials and various cleansers are delivered. The transfer of goods from incoming trucks to storage areas is a source of pollution. Although no problems were noticed, the pollution prevention team has developed a spill prevention and response plan to clean up spills quickly and report them if necessary.
- The last area we inspected was the runoff field below the employee parking lot. Here we noticed a significant amount of erosion resulting from recent construction to expand the parking lot.

Describe existing management practices.

Grass was lightly planted around the parking lot after recent construction. The fuel storage tank has curbing around it in accordance with our SPCC plan. Also, the maintenance crew regularly picks up trash and empty containers from around the storage tanks, loading and unloading areas, and the vehicle washing areas. Used oils are collected in containers and taken to a recycling facility. In addition, we installed two oil/water separators at the drains into our underground storm sewer leading to the Rocky River. These separators are indicated on the site map.

C-20

Double Scoop Ice Cream Company

Existing Monitoring Data

Although our NPDES permit for process wastewater does not require storm water sampling, we sampled our storm water on one occasion in response to a questionnaire we received from the National Association of Ice Cream Makers. They were collecting information to submit as part of their comments on EPA's proposed general permit.

| | |
|-------------------------|--|
| Date of Sampling | 8/30/91 |
| Outfall Sampled | 001 |
| Type of Storm | 1 inch light rainfall (lasted 2 days) |
| Type of Samples | Grab samples taken during first hour of flow |

| Data | | |
|------------------|-----------------|--------------------|
| Parameter | Quantity | Sample Type |
| BOD | 250 mg/l | Grab |
| TSS | 100 mg/l | Grab |
| pH | 7.2 s.u. | Grab |
| Oil and grease | 5.0 mg/l | Grab |

Based upon the high concentration of BOD in the storm water samples collected, pollution prevention team is considering possible potential sources of BOD. We will look at storage areas housing butter fat, milk, and whey solids tanks.

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Double Scoop Ice Cream Company

Summary of Pollutant Sources

March 5, 1993

Based on the site assessment inspection conducted on 12/1/92, the pollution prevention team identified four potential sources of pollutants:

- Oil and grease stains on the pavement in the fueling area indicate oil and grease may be picked up by storm water draining to the storm sewer. This area drains into the storm sewer leading to the Rocky River.
- Sediment and erosion potential in the field below the employee parking lot because of thinly planted grass.
- Potential for spills or leaks from liquid storage tanks, including the fuel storage tank, based on a spill that occurred on 1/21/92 and the leak that was detected in the milk storage tank. These pollutants would drain into the piped outfall into the Rocky River.
- Use of a toxic cleaning agent may result in a pollution problem if handled improperly.

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Double Scoop Ice Cream Company

**Description of Storm Water Management Measures Taken
Based on Site Assessment Phase**

March 5, 1993

These measures correspond to the pollutant sources identified on the preceding page.

Oil and grease from fueling area.

We installed drip pads around the fuel pumps to pick up spilled gas and oil during truck refueling. These will be inspected regularly to make sure they are working well.

Sediment and erosion in the field below the employee parking lot.

We planted grass in this area to reduce potential for erosion.

Leaks/spills from liquid storage tanks.

We are in the process of installing curbing around the outdoor liquid storage tanks that will contain the volume of the largest tank in case a spill should occur. The spill response team has developed procedures to clean up this area should a spill occur. We are incorporating spill response procedures from our SPCC plan.

Toxic cleaning agent.

We have discontinued the use of this agent and are replacing it with a non-toxic cleaning agent.

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POLLUTANT SOURCE IDENTIFICATION
(Section 2.2.6)

Worksheet #7

Completed by: Cheryl Glenn

Title: Plant Manager

Date: 3/5/93

Instructions: List all identified storm water pollutant sources and describe existing management practices that address those sources. In the third column, list BMP options that can be incorporated into the plan to address remaining sources of pollutants.

| Storm Water Pollutant Sources | Existing Management Practices | Description of New BMP Options |
|---|---|--|
| 1. Oil and grease on pavement in fueling area | Oil and water separators installed in storm water drain | Install drip pads |
| 2. Erosion in field below employee parking lot | Planted some grass after construction; grassed swales along Wontka Drive | Plant more grass |
| 3. Potential for spills from liquid storage tanks (leak detected in milk tank #1 + past spill on 1/21/92) | Curbing around fuel storage tank (see SPCC plan) | Replace milk tank #1; replace valve on liquid sugar tank #2; install curbing around other outside tanks; spill prevention response plan; inspect |
| 4. Use of toxic cleaning agent. | | Use non-toxic cleaning agent |
| 5. Trash in loading/unloading fueling areas | Regular trash pickup (daily) by maintenance crew; collect and recycle used oil. | Train staff in good housekeeping practices. |
| 6. | | |
| 7. | | |
| 8. | | |
| 9. | | |
| 10. | | |

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BMP IDENTIFICATION
(Section 2.3.1)

Worksheet #7a

Completed by: Cheryl Glenn

Title: Plant Manager

Date: 3/5/93

Instructions: Describe the Best Management Practices that you have selected to include in your plan. For each of the baseline BMPs, describe actions that will be incorporated into facility operations. Also describe any additional BMPs [activity-specific (Chapter 3) and site-specific BMPs (Chapter 4)] that you have selected. Attach additional sheets if necessary.

| BMPs | Brief Description of Activities |
|--|--|
| Good Housekeeping | Collect and recycle used oil; regular trash pick up; train staff in basic clean up procedures (sweeping loading & unloading areas, etc.) |
| Preventive Maintenance | Daily inspection of outside milk tanks; replace faulty valve on sugar tank #2; replace leaking milk tank #1 |
| Inspections | Daily inspection of outside milk tanks; bi-monthly inspections of drip pads, curbing, loading/unloading areas, grassed areas, drainage system. |
| Spill Prevention Response | Install curbing around outside liquid storage tanks; fuel tank has curbing; install drip pads at fueling station. |
| Sediment and Erosion Control | Plant grass around new parking area. |
| Management of Runoff | Grassed swales along Wonka Drive; (2) oil/water separators in storm drain system |
| Additional BMPs (Activity-specific and Site-specific) | Order non-toxic cleaning agent. |

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Double Scoop Ice Cream Company

Employee Training Program

Who:

Line Workers
Maintenance Crew
Shipping and Receiving Crew

When:

Employee meetings held the first Monday of each month to discuss:

- Any environmental/health and safety incidents
- Upcoming training sessions
- Brief reminders on good housekeeping, spill prevention and response procedures, and material handling practices
- Announce any changes to the plan
- Announce any new management practices

In-depth pollution prevention training for new employees

Refresher courses held every 6 months (October and March) addressing:

- Good housekeeping
- Spill prevention and response procedures
- Materials handling and storage

Employee Training Program Topics:

Good Housekeeping

- Review and demonstrate basic cleanup (sweeping and vacuuming) procedures.
- Clearly indicate proper disposal locations.
- Post signs in materials handling areas reminding staff of good housekeeping procedures.
- Be sure employees know where routine clean-up equipment is located.

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Spill Prevention and Response

- Clearly identify potential spill areas and drainage routes
- Familiarize employees with past spill events -- why they happened and the environmental impact (use slides)
- Post warning signs in spill areas with emergency contacts and telephone numbers
- Introduce Isaac Feldman as the Spill Response Coordinator and introduce his "team"
- Drill on spill clean-up procedures
- Post the locations of spill clean-up equipment and the persons responsible for operating the equipment

Materials Handling and Storage

- Be sure employees are aware which materials are hazardous and where those materials are stored
- Point out container labels
- Tell employees to use the oldest materials first
- Explain recycling practices
- Demonstrate how valves are tightly closed and how drums should be sealed
- Show how to fuel vehicles and avoid "topping off"

IMPLEMENTATION
(Section 2.4.1)

Worksheet #8
Completed by:
Title:
Date:

Cheryl Glenn
Plant Manager
3/30/93

Instructions: Develop a schedule for implementing each BMP. Provide a brief description of each BMP, the steps necessary to implement the BMP (i.e., any construction or design), the schedule for completing those steps (list dates) and the person(s) responsible for implementation.

| BMPs | Description of Action(s) Required for Implementation | Scheduled Completion Date(s) for Req'd. Action | Person Responsible for Action | Notes |
|--|--|--|-------------------------------|-------|
| Good Housekeeping | 1. <i>Develop training program</i> | <i>3/10/93</i> | <i>Glenn</i> | |
| | 2. <i>Conduct training</i> | <i>6/1/93</i> | <i>Glenn</i> | |
| | 3. | | | |
| Preventive Maintenance | 1. <i>Replace valve on sugar tank #2</i> | <i>3/1/93</i> | <i>Feldman</i> | |
| | 2. <i>Install new milk tank #2</i> | <i>2/15/93</i> | <i>Feldman</i> | |
| | 3. | | | |
| Inspections | 1. <i>Develop inspections schedule</i> | <i>4/1/93</i> | <i>Glenn</i> | |
| | 2. | | | |
| | 3. | | | |
| Spill Prevention and Response | 1. <i>Install curbing around milk storage tanks</i> | <i>4/30/93</i> | <i>Meyers</i> | |
| | 2. <i>Install drip pads</i> | <i>4/1/93</i> | <i>Feldman</i> | |
| | 3. <i>Develop / Implement Spill Prevention / Response Training</i> | <i>4/1/93 - DEVELOP 6/1/93 - TRAIN</i> | <i>Feldman</i> | |
| Sediment and Erosion Control | 1. <i>Plant grass around parking area</i> | <i>4/15/93</i> | <i>Feldman</i> | |
| | 2. | | | |
| | 3. | | | |
| Management of Runoff | 1. <i>BMPs already in place</i> | | | |
| | 2. | | | |
| | 3. | | | |
| Additional BMPs (Actively-specific and site-specific) | 1. <i>Substitute non-toxic cleaning agent</i> | <i>2/28/93</i> | <i>Michaels</i> | |
| | 2. | | | |
| | 3. | | | |

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EMPLOYEE TRAINING
(Section 2.4.2)

Worksheet #9

Completed by: Cheryl Glenn

Title: Plant Manager

Date: 3/2/93

Instructions: Describe the employee training program for your facility below. The program should, at a minimum, address spill prevention and response, good housekeeping, and material management practices. Provide a schedule for the training program and list the employees who attend training sessions.

| Training Topics | Brief Description of Training Program/Materials (e.g., film, newsletter course) | Schedule for Training (list dates) | Attendees |
|-------------------------------|---|--------------------------------------|--|
| Spill Prevention and Response | locate spill areas by signs; drill spill response procedures; show slides of past spills. | October / March | Maintenance / shipping & receiving |
| Good Housekeeping | Demonstration; post signs at disposal sites. | October / March | Maintenance / shipping & receiving |
| Material Management Practices | introduce hazardous materials labels; discuss recycling. | October / March | Lineworkers / shipping and receiving / maintenance |
| Other Topics | Environmental / health incidents; Reminders of pollution prevention plan issues. | 1 st Monday of each month | All employees. |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

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APPENDIX D

**STORM WATER AND POLLUTION PREVENTION CONTACTS
AND ADDITIONAL POLLUTION PREVENTION INFORMATION**

| STATE STORM WATER AND POLLUTION PREVENTION CONTACTS | | |
|---|-------------------------------------|---|
| State | Storm Water Contact | Pollution Prevention Contact |
| *Alabama | John Poole 205-271-7852 | Daniel E. Cooper 205-271-7939 |
| Alaska | Michael Menge 907-465-5260 | David Wigglesworth 907-465-5275 |
| Arizona | See Region IX Contact | Stephanie Wilson 602-257-2318 |
| *Arkansas | Marysia Jastrzebski 501-562-7444 | Robert J. Finn 501-570-2861 |
| *California | Don Parrin 916-657-1288 | Kim Wilhelm 916-324-1807 |
| *Colorado | Patricia Nelson 303-331-4590 | Kate Kramer 303-331-4510 |
| *Connecticut | Dick Mason 203-566-7167 | Rita Lomasney (ConnTap) 203-241-0777 |
| *Delaware | Sarah Cooksey 302-739-5731 | Andrea Farrell 302-739-3822 |
| District of Columbia | James Collier 202-404-1120 | Hampton Cross 202-939-7116 |
| Florida | Eric Livingston 904-488-0782 | Janet A. Campbell 904-488-0300 |
| *Georgia | Mike Creason 404-656-4887 | Susan Hendricks 404-656-2833 |
| *Hawaii | Steve Chang 808-586-4309 | Jane Dewell 808-586-4226 |
| Idaho | Jerry Yoder 208-334-5898 | Joy Palmer 208-334-5879 |
| *Illinois | Tim Kluge 217-782-0610 | Mike Hayes 217-782-8700 |
| *Indiana | Lonnie Brumfield 317-232-8705 | Joanna Joyce 317-232-8172 |
| *Iowa | Monica Wnuk 515-281-7017 | John Konefes 319-273-2079 |
| *Kansas | Don Carlson 913-296-5555 | Tom Gross 913-296-1603 |
| *Kentucky | Douglas Allgeier 502-564-3410 | Joyce St. Clair 502-588-7260 |

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| STATE STORM WATER AND POLLUTION PREVENTION CONTACTS | | |
|---|-------------------------------------|---------------------------------------|
| State | Storm Water Contact | Pollution Prevention Contact |
| Louisiana | Jim Delahoussaye 504-765-0525 | Gary Johnson 504-765-0720 |
| Maine | Norm Marcotte 207-289-3901 | Scott Whittier 207-289-2651 |
| *Maryland | Vince Berg 410-631-3553 | Harry Benson 301-631-3315 |
| Massachusetts | Cynthia Hall 617-292-5656 | Barbara Kelly 617-727-3260 |
| *Michigan | Gary Boersen 517-373-1982 | Larry E. Hartwig 517-335-1178 |
| *Minnesota | Scott Thompson 612-296-7203 | Cindy McComas (MNTAP) 612-296-4646 |
| *Mississippi | Jerry Cain 601-961-5171 | Caroline Hill 601-325-8454 |
| *Missouri | Bob Hentges 314-751-6825 | Becky Shannon 314-751-3176 |
| *Montana | Fred Shewman 406-444-2406 | Bill Potts 406-444-2821 |
| *Nebraska | Clark Smith 402-471-4239 | Teri Swarts 402-471-4217 |
| *Nevada | Rob Saunders 702-687-4670 | Kevin Dick 702-784-1717 |
| New Hampshire | Jeff Andrews 603-271-2457 | Vincent R. Perelli 603-271-2902 |
| *New Jersey | Sandra Cohen 609-633-7021 | Jean Herb 609-777-0518 |
| New Mexico | Glen Saums 505-827-2827 | Alex Puglisi 505-827-2804 |
| *New York | Ken Stevens 518-457-1157 | John Ianotti 518-457-7267 |
| *North Carolina | Coleen Sullins 919-733-5083 | Gary Hunt 919-571-4100 |
| *North Dakota | Sheila McClenatahan 701-221-5210 | Neil Knatterud 703-221-5166 |
| *Ohio | Robert Phelps 614-644-2034 | Mike Kelly 614-644-3492 |

*Approved NPDES Program

| STATE STORM WATER AND POLLUTION PREVENTION CONTACTS | | |
|---|--------------------------------------|---|
| State | Storm Water Contact | Pollution Prevention Contact |
| Oklahoma | Brooks Kirlin 504-231-2500 | Chris Varga 405-271-7047 |
| *Oregon | Ranei Nomura 503-229-5256 | Roy W. Brower 503-229-6585 |
| *Pennsylvania | R.B. Patel 717-787-8184 | Greg Harder 717-772-2724 |
| *Rhode Island | Ed Symanski 401-244-3931 | Janet Keller 401-277-3434 |
| *South Carolina | Brigit McDade 803-734-5300 | Jeffrey DeBossonet 803-734-4715 |
| South Dakota | Glenn Pieritz 605-773-3351 | Vonnie Kallmeyn 605-773-3153 |
| *Tennessee | Robert Haley 615-741-2275 | James Ault 615-742-6547 |
| Texas | Randy Wilburn 512-463-8446 | Priscilla Seymour 512-463-7761 |
| *Utah | Harry Campbell 801-538-6146 | Sonja Wallace 801-538-6170 |
| *Vermont | Brian Kooiker 802-244-5674 | Gary Gulka 802-244-8702 |
| *Virgin Islands | Marc Pacifico 809-773-0565 | See Region II Contact |
| *Virginia | Martin Ferguson, Jr. 804-527-5030 | Sharon Kenneally-Baxter 804-371-8716 |
| *Washington | Peter Birch 206-438-7076 | Stan Springer 206-438-7541 |
| *West Virginia | Jerry Ray 304-348-0375 | Dale Moncer 304-348-4000 |
| *Wisconsin | Ann Mauel 608-267-7634 | Lynn Persson 608-267-3763 |
| *Wyoming | John Wagner 307-777-7082 | David Finley 307-777-7752 |

*Approved NPDES Program

| EPA REGIONAL STORM WATER AND POLLUTION PREVENTION CONTACTS | | |
|---|-------------------------------------|-------------------------------------|
| State | Storm Water Contact | Pollution Prevention Contact |
| REGION I | Veronica Harrington 617-565-3525 | Mark Mahoney 617-565-1155 |
| REGION II | Jose Rivera 212-264-2911 | Janet Sapadin 212-264-1925 |
| REGION III | Kevin Magerr 215-597-1651 | Roy Denmark 215-597-8327 |
| REGION IV | Roosevelt Childress 404-347-3379 | Carol Monell 404-347-7109 |
| REGION V | Peter Swenson 312-886-0236 | Louis Blume 312-353-4135 |
| REGION VI | Brent Larsen 214-655-7175 | Laura Townsend 214-655-6525 |
| REGION VII | Ralph Summers 913-551-7418 | Alan Wehmeyer 913-551-7336 |
| REGION VIII | Vern Berry 303-293-1630 | Sharon Childs 303-293-1456 |
| REGION IX | Eugene Bromley 415-744-1906 | Jesse Baskir 415-744-2189 |
| REGION X | Steve Bubnick 206-553-8399 | Carolyn Gangmark 206-553-4072 |

ADDITIONAL POLLUTION PREVENTION INFORMATION

State pollution prevention programs have people who are knowledgeable about pollution prevention and are willing to provide information and sometimes technical assistance on pollution prevention. The EPA has pollution prevention experts located in a number of different program offices, laboratories, and EPA Regional offices. These experts can provide information on starting a pollution prevention program or on specific waste reduction BMPs. This Appendix lists State and Federal pollution prevention contacts above. Trade associations are another good source of pollution prevention information. Trade associations can often provide you with pollution prevention assistance directly or refer you to someone who can.

A comprehensive listing of pollution prevention resources, documents, courses, and programs, including names and phone numbers, is contained in a new annual EPA publication. Copies of this document -- *Pollution Prevention Training Opportunities in 1992* -- may be obtained by calling the PPIC/PIES support number at (703) 821-4800.

One good source of information on pollution prevention is EPA's Pollution Prevention Information Clearinghouse (PPIC). PPIC contains technical, policy, programmatic, legislative, and financial information on pollution prevention efforts in the United States and abroad. The PPIC may be reached by personal computer modem, telephone hotline, or mail. The PIES, or Pollution Prevention Information Exchange System, is a free 24-hour electronic bulletin board consisting of message centers, technical data bases, issue-specific "mini-exchanges," and a calendar of pollution prevention events. The PIES allows a user to access the full range of information in the PPIC. For information on how to use the PPIC/PIES, call (703) 821-4800. To log on to the PIES system using a modem and a PC, call (703) 506-1025 (set your communication software at 8 bits and no parity).

EPA and State programs have developed manuals and fact sheets containing specific pollution prevention information. These manuals and fact sheets listed below can be ordered free of charge by calling the EPA Pollution Prevention Information Clearinghouse at (703) 821-4800.

**INDUSTRY-SPECIFIC POLLUTION PREVENTION GUIDANCE MANUALS
AVAILABLE FROM THE PPIC**

| | | |
|--|---|------------------|
| <i>Guides to Pollution Prevention:</i> | <i>Automotive Refinishing Industry</i> | EPA/625/7-91/016 |
| <i>Guides to Pollution Prevention:</i> | <i>Auto Repair Industry</i> | EPA/625/7-91/013 |
| <i>Guides to Pollution Prevention:</i> | <i>The Commercial Printing Industry</i> | EPA/625/7-90/008 |
| <i>Guides to Pollution Prevention:</i> | <i>The Fabricated Metal Industry</i> | EPA/625/7-90/006 |
| <i>Guides to Pollution Prevention:</i> | <i>Fiberglass Reinforced and Composite Plastics</i> | EPA/625/7-91/014 |
| <i>Guides to Pollution Prevention:</i> | <i>Marine Maintenance and Repair</i> | EPA/625/7-91/015 |
| <i>Guides to Pollution Prevention:</i> | <i>The Paint Manufacturing Industry</i> | EPA/625/7-90/005 |
| <i>Guides to Pollution Prevention:</i> | <i>The Pesticide Formulating Industry</i> | EPA/625/7-90/004 |
| <i>Guides to Pollution Prevention:</i> | <i>Pharmaceutical Preparation</i> | EPA/625/7-91/017 |
| <i>Guides to Pollution Prevention:</i> | <i>Photoprocessing Industry</i> | EPA/625/7-91/012 |
| <i>Guides to Pollution Prevention:</i> | <i>The Printed Circuit Board Manufacturing Industry</i> | EPA/625/7-90/00 |
| <i>Guides to Pollution Prevention:</i> | <i>Research and Educational Institutions</i> | EPA/625/7-90/010 |
| <i>Guides to Pollution Prevention:</i> | <i>Selected Hospital Waste Streams</i> | EPA/625/7-90-009 |

FACT SHEETS AVAILABLE FROM PPIC

General/Introductory Information

- Conservation Tips for Business
- General Guidelines
- Getting More Use Out of What We Have
- Glossary of Waste Reduction Terms
- Guides to Pollution Prevention
- Hazardous Waste Fact Sheet for Minnesota Generators
- Hazardous Waste Minimization
- How Business Organizations Can Help
- Increase Your Corporate and Product Image
- Industrial Hazardous Wastes in Minnesota
- Local Governments and Pollution Prevention
- Pollution Prevention (General)
- Pollution Prevention Fees
- Pollution Prevention Training and Education
- Pollution Prevention Through Waste Reduction
- Recent Publications
- Reduce Hazardous Waste
- Reuse Strategies for Local Government
- Source Reduction Techniques for Local Government
- U.S. EPA's Pollution Prevention Program
- Video Tapes Available from the Virginia Waste Minimization Program
- Waste Exchange: Everybody Wins!
- Waste Exchange Services
- Waste Minimization Fact Sheet

- Waste Minimization in the Workplace
- Waste Reduction Can Work For You
- Waste Reduction Overview
- Waste Reduction/Pollution Prevention: Getting Started
- Waste Reduction Tips for All Businesses
- Waste Source Reduction Checklist
- What is Pollution Prevention?
- Why Reduce Waste?

**Legislative Information/
EPA and State Initiatives**

- About Minnesota's "But Recycled Campaign"
- Alaska State Agency Waste Reduction and Recycling
- EPA's 2% Set Aside Pollution Prevention Projects
- EPA's "List of Lists" Projects
- EPA's Pollution Prevention Enforcement Settlement Policy
- EPA's Pollution Prevention Incentives for States
- EPA's Pollution Prevention Strategy
- Introducing the Colorado Pollution Prevention Program
- Michigan's Solid Waste Reduction Strategy
- Minnesota's Toxic Pollution Prevention Act
- New Form R Reporting Requirements
- Oregon's Toxic Use Reduction Act
- Pollution Prevention Act of 1990
- Promoting Pollution Prevention in Minnesota State Government

Setting Up A Program

- 1991 Small Business Pollution Prevention Grants
- An Organization Strategy for Pollution Prevention
- Considerations in Selecting a Still for Onsite Recycling
- Colorado Technical Information Center
- Onsite Assistance (Colorado only)
- Pollution Prevention Grant Program Summaries and Reports
- Procuring Recycled Products
- Recycling Market Development Program
- Selecting a Supplier, Hauler, and Materials Broker
- Solid Waste Management Financial Assistance Program
- Source Reduction at Your Facility
- Starting Your Own Waste Reduction Program
- The Alexander Motor's Success Story
- The Eastside Plating Success Story
- The Tektronics Payoff
- The Wacker Payoff
- Waste Reduction Checklists:
 - General
 - Cleaning
 - Coating/Painting
 - Formulating
 - Machining
 - Operating Procedures
 - Plating/Metal Finishing

- Waste Source Reduction: Implementing a Program

Process/Material Specific

- Aerosol Containers
- Aircraft Rinsewater Disposal
- Acids/Bases
- Chemigation Practices to Prevent Ground Water Contamination
- Corrugated Cardboard Waste Reduction
- Demolition
- Empty Containers
- Gunwasher Maintenance
- Lead Acid Batteries
- Machine Coolants:
 - Prolonging Coolant Life
 - Waste Reduction
- Metal Recovery:
 - Dragout Reduction
 - Ion Exchange/Electrolytic Recovery
 - Etchant Substitution
- Metals Recycling
- Office Paper Waste Reduction
- Old Paints, Inks, Residuals, and Related Materials
- Pesticides:
 - Disposal of Unused Pesticides, Tank Mixes, and Rinsewater
 - In-Filled Sprayer Rinse System to Reduce Pesticide Wastes
 - Pesticide Container Disposal
 - Preventing Pesticide Pollution of Surface and Ground Water

- Preventing Well Contamination by Pesticides
- Protecting Mountain Springs from Pesticide Contamination
- Reducing and Saving Money Using Integrated Pest Management
- **Plastics:**
 - The Facts About Production, Use, and Disposal
 - The Facts on Degradable Plastics
 - The Facts on Recycling Plastics
 - The Facts on Source Reduction
- **Printing Equipment**
- **Refrigerant Reclamation Equipment/ Services**
- **Reverse Osmosis**
- **Safety Kleen, Inc., Users**
- **Shop Rags from Printers**
- **Small Silver Recovery Units**
- **Solvents:**
 - Alternatives to CFC-113 Used in the Cleaning of Electronic Circuit Boards
 - Onsite Solvent Reclamation
 - Reducing Shingle Waste at a Manufacturing Facility
 - Reducing Solvent Emissions from Vapor Degreasers
 - Small Solvent Recovery Systems
 - Solvent Loss Control
 - Solvent Management: Printing Press
 - Solvent Recovery: Fiber Production Plant
 - Solvent Reduction in Metal Parts Cleaning
- Solvent Reuse: Technical Institute
- Trichloroethylene and Stoddard Solvent Reduction Alternatives
- **Ultrafiltration**
- **Used Containers: Management**
- **Used Oil Recycling**
- **Waste Management Guidance for Oil Clean-Up**
- **Water and Chemical Reduction for Cooling Towers**
- **Waste Water Treatment Opportunities**

Industry-Specific Information

- **Aerospace Industry**
- **Auto Body Shops**
- **Automotive Painting**
- **Automotive/Vehicle Repair Shops**
- **Auto Salvage Yards**
- **Asbestos Handling, Transport, and Disposal**
- **Chemical Production**
- **Coal Mining**
- **Concrete Panel Manufacturers**
- **Dairy Industry:**
 - Cut Waste and Reduce Surcharges for Your Dairy Plant
 - Dairy CEOs: Do You Have a \$500 Million Opportunity?
 - Liquid Assets for Your Dairy Plant
 - Water and Wastewater Management in a Dairy Processing Plant
- **Dry Cleaners**
- **Electrical Power Generators**

- **Electroplating Industry:**
 - Dragout Management for Electroplaters
 - Plating with Trivalent Chrome Instead of Cr+6
 - Water Conservation Using Counter Current Rinsing
 - Water Conservation: Tank Design
 - Water Conservation: Rinsewater Reuse
 - What Should I Do With My Electroplating Sludge?
- **Fabricated Metal Manufacturers**
- **Fiberglass Fabricators: Volatile Emissions Reduction**
- **Machine Toolers**
- **Metal Finishers:**
 - General
 - Effluent Minimization
 - Rinsewater Reduction
- **Oil Refiners**
- **Paint Formulators**
- **Paper Manufacturers**
- **Pesticide Formulating Industry**
- **Photofinishers/Photographic Processors**
- **Poultry Industry:**
 - Poultry CEOs: You May Have a \$60 Million Opportunity
 - Poultry Processors: You Can Reduce Waste Load and Cut Sewer Surcharges
 - Survey Shows That Poultry Processors Can Save Money By Conserving Water
 - Systems for Recycling Water in Poultry Processing
- **Printed Circuit Board Manufacturers**
- **Printing Industry**
- **Radiator Service Firms**
- **Shrimp Processors**
- **Steel Manufacturers**
- **Textile Industry:**
 - Dye Bath and Bleach Bath Reconstitution
 - Water Conservation
- **Wire Milling Operations: Process Water Reduction**

APPENDIX E
BMP FACT SHEETS

SILT FENCE

September 1992

Design Criteria

- ▲ Silt fences are appropriate at the following general locations:
 - ▲ Immediately upstream of the point(s) of runoff discharge from a site before flow becomes concentrated (maximum design flow rate should not exceed 0.5 cubic feet per second).
 - ▲ Below disturbed areas where runoff may occur in the form of overland flow.
- ▲ Ponding should not be allowed behind silt fences since they will collapse under high pressure; the design should provide sufficient outlets to prevent overtopping.
- ▲ The drainage area should not exceed 0.25 acre per 100 feet of fence length.
- ▲ For slopes between 50:1 and 5:1, the maximum allowable upstream flow path length to the fence is 100 feet; for slopes of 2:1 and steeper, the maximum is 20 feet.
- ▲ The maximum upslope grade perpendicular to the fence line should not exceed 1:1.
- ▲ Synthetic silt fences should be designed for 6 months of service; burlap is only acceptable for periods of up to 60 days.

Materials

- ▲ Synthetic filter fabric should be a pervious sheet of polypropylene, nylon, polyester, or polyethylene yarn conforming to the requirements in Table 1 below.

TABLE 1. SYNTHETIC FILTER FABRIC REQUIREMENTS

| Physical Property | Requirements |
|--|---|
| Filtering Efficiency | 75% - 85% (minimum) |
| Tensile Strength at 20% (maximum) Elongation | Standard Strength - 30 lb/linear inch (minimum) |
| | Extra Strength - 50 lb/linear inch (minimum) |
| Slurry Flow Rate | 0.3 gal/ft ² /min (minimum) |

- ▲ Synthetic filter fabric should contain ultraviolet ray inhibitors and stabilizers to provide a minimum of 6 months of expected usable construction life at a temperature range of 0 to 120°F.
- ▲ Burlap of 10 ounces per square yard of fabric can also be used.
- ▲ The filter fabric should be purchased in a continuous roll to avoid joints.
- ▲ While not required, wire fencing may be used as a backing to reinforce standard strength filter fabric. The wire fence (14 gauge minimum) should be at 22-48 inches wide and should have a maximum mesh spacing of 6 inches.
- ▲ Posts should be 2-4 feet long and should be composed of either 2" x 2-4" pine (or equivalent) or 1.00 to 1.33 lb/linear ft steel. Steel posts should have projections for fastening wire and fabric to them.

Construction Specifications

- ▲ The maximum height of the filter fence should range between 18 and 36 inches above the ground surface (depending on the amount of upslope ponding expected).

SILT FENCE

- ▲ Posts should be spaced 8 to 10 feet apart when a wire mesh support fence is used and no more than 6 feet apart when extra strength filter fabric (without a wire fence) is used. The posts should extend 12 to 30 inches into the ground.
- ▲ A trench should be excavated 4 to 8 inches wide and 4 to 12 inches deep along the upslope side of the line of posts.
- ▲ If standard strength filter fabric is to be used, the optional wire mesh support fence may be fastened to the upslope side of the posts using 1 inch heavy duty wire staples, tie wires, or hog rings. Extend the wire mesh support to the bottom of the trench. The filter fabric should then be stapled or wired to the fence, and 8 to 20 inches of the fabric should extend into the trench (Figure 1).
- ▲ Extra strength filter fabric does not require a wire mesh support fence. Staple or wire the filter fabric directly to the posts and extend 8 to 20 inches of the fabric into the trench (Figure 1).
- ▲ Where joints in the fabric are required, the filter cloth should be spliced together only at a support post, with a minimum 6-inch overlap, and securely sealed.
- ▲ Do not attach filter fabric to trees.
- ▲ Backfill the trench with compacted soil or 0.75 inch minimum diameter gravel placed over the filter fabric.

Maintenance

- ▲ Inspect filter fences daily during periods of prolonged rainfall, immediately after each rainfall event, and weekly during periods of no rainfall. Make any required repairs immediately.
- ▲ Sediment must be removed when it reaches one-third to one-half the height of the filter fence. Take care to avoid damaging the fence during cleanout.
- ▲ Filter fences should not be removed until the upslope area has been permanently stabilized. Any sediment deposits remaining in place after the filter fence has been removed should be dressed to conform with the existing grade, prepared, and seeded.

Cost

- ▲ Silt fence installation costs approximately \$6.00 per linear foot.

Sources

- ▲ Commonwealth of Virginia - County of Fairfax, 1987. 1987 Check List For Erosion And Sediment Control - Fairfax County, Virginia.
- ▲ State of North Carolina, 1988. Erosion and Sediment Control Planning and Design Manual. North Carolina Sedimentation Control Commission, Department of Natural Resources and Community Development.
- ▲ Maryland Department of the Environment, 1991. 1991 Maryland Standards And Specifications For Soil Erosion And Sediment Control - Draft.

PIPE SLOPE DRAIN

September 1992

Design Criteria

- ▲ Pipe Slope Drains (PSD) are appropriate in the following general locations:
 - ▲ On cut or fill slopes before permanent storm water drainage structures have been installed.
 - ▲ Where earth dikes or other diversion measures have been used to concentrate flows.
 - ▲ On any slope where concentrated runoff crossing the face of the slope may cause gullies, channel erosion, or saturation of slide-prone soils.
 - ▲ As an outlet for a natural drainageway.
- ▲ The drainage area may be up to 10 acres; however, many jurisdictions consider 5 acres the recommended maximum.
- ▲ The PSD design should handle the peak runoff for the 10-year storm. Typical relationships between area and pipe diameter are shown in Table 2 below.

TABLE 2. RELATIONSHIP BETWEEN AREA AND PIPE DIAMETER

| Maximum Drainage Area (Acres) | Pipe Diameter (D) (Inches) |
|----------------------------------|-------------------------------|
| 0.5 | 12 |
| 0.75 | 15 |
| 1.0 | 18 |

Materials

- ▲ Pipe may be heavy duty flexible tubing designed for this purpose, e.g., nonperforated, corrugated plastic pipe, corrugated metal pipe, bituminous fiber pipe, or specially designed flexible tubing.
- ▲ A standard flared end section secured with a watertight fitting should be used for the inlet. A standard T-section fitting may also be used.
- ▲ Extension collars should be 12-inch long sections of corrugated pipe. All fittings must be watertight.

Construction Specifications

- ▲ Place the pipe slope drain on undisturbed or well-compacted soil.
- ▲ Soil around and under the entrance section must be hand-tamped in 4-inch to 8-inch lifts to the top of the dike to prevent piping failure around the inlet.
- ▲ Place filter cloth under the inlet and extend 5 feet in front of the inlet and be keyed in 6-inches on all sides to prevent erosion. A 6-inch metal toe plate may also be used for this purpose.
- ▲ Ensure firm contact between the pipe and the soil at all points by backfilling around and under the pipe with stable soil material hand compacted in lifts of 4-inches to 8-inches.
- ▲ Securely stake the PSD to the slope using grommets provided for this purpose at intervals of 10 feet or less.
- ▲ Ensure that all slope drain sections are securely fastened together and have watertight fittings.

PIPE SLOPE DRAIN

- ▲ Extend the pipe beyond the toe of the slope and discharge at a nonerosive velocity into a stabilized area (e.g., rock outlet protection may be used) or to a sedimentation trap or pond.
- ▲ The PSD should have a minimum slope of 3 percent or steeper.
- ▲ The height at the centerline of the earth dike should range from a minimum of 1.0 foot over the pipe to twice the diameter of the pipe measured from the invert of the pipe. It should also be at least 6 inches higher than the adjoining ridge on either side.
- ▲ At no point along the dike will the elevation of the top of the dike be less than 6 inches higher than the top of the pipe.
- ▲ Immediately stabilize all areas disturbed by installation or removal of the PSD.

Maintenance

- ▲ Inspect regularly and after every storm. Make any necessary repairs.
- ▲ Check to see that water is not bypassing the inlet and undercutting the inlet or pipe. If necessary, install headwall or sandbags.
- ▲ Check for erosion at the outlet point and check the pipe for breaks or clogs. Install additional outlet protection if needed and immediately repair the breaks and clean any clogs.
- ▲ Do not allow construction traffic to cross the PSD and do not place any material on it.
- ▲ If a sediment trap has been provided, clean it out when the sediment level reaches 1/3 to 1/2 the design volume.
- ▲ The PSD should remain in place until the slope has been completely stabilized or up to 30 days after permanent slope stabilization.

Cost

- ▲ Pipe slope drain costs are generally based upon the pipe type and size (generally, flexible PVC at \$5.00 per linear foot). Also adding to this cost are any expenses associated with inlet and outlet structures.

Sources

- ▲ Commonwealth of Virginia - County of Fairfax, 1987. 1987 Check List For Erosion And Sediment Control - Fairfax County, Virginia.
- ▲ State of North Carolina, 1988. Erosion and Sediment Control Planning and Design Manual. North Carolina Sedimentation Control Commission, Department of Natural Resources and Community Development.
- ▲ Maryland Department of the Environment, 1991. 1991 Maryland Standards And Specifications For Soil Erosion And Sediment Control - Draft.
- ▲ Storm Water Management Manual for the Puget Sound Basin. State of Washington, Department of Ecology, 1991.
- ▲ Cost Data:
 - ▲ Draft Sediment and Erosion Control, An Inventory of Current Practices, April 20, 1990. Prepared by Kamber Engineering for the U.S. Environmental Protection Agency, Office of Water Enforcement and Permits, Washington, D.C. 20460.

FILTER FABRIC INLET PROTECTION

September 1992

Design Criteria

- ▲ Inlet protection is appropriate in the following locations:
 - ▲ In small drainage areas (less than 1 acre) where the storm drain inlet is functional before the drainage area has been permanently stabilized.
 - ▲ Where there is danger of sediment silting in an inlet which is in place prior to permanent stabilization.
- ▲ Filter fabric inlet protection is appropriate for most types of inlets where the drainage area is one acre or less.
- ▲ The drainage area should be fairly flat with slopes of 5% or less and the area immediately surrounding the inlet should not exceed a slope of 1%.
- ▲ Overland flow to the inlet should be no greater than 0.5 cfs.
- ▲ This type of inlet protection is not appropriate for use in paved areas because the filter fabric requires staking.
- ▲ To avoid failure caused by pressure against the fabric when overtopping occurs, it is recommended that the height of the filter fabric be limited to 1.5 feet above the crest of the drop inlet.
- ▲ It is recommended that a sediment trapping sump of 1 to 2 feet in depth with side slopes of 2:1 be provided.

Materials

- ▲ Filter fabric (see the fabric specifications for silt fence).
- ▲ Wooden stakes 2" x 2" or 2" x 4" with a minimum length of 3 feet.
- ▲ Heavy-duty wire staples at least ½ inch in length.
- ▲ Washed gravel ¾ inches in diameter.

Construction Specifications

- ▲ Place a stake at each corner of the inlet and around the edges at no more than 3 feet apart. Stakes should be driven into the ground 18 inches or at a minimum 8 inches.
- ▲ For stability a framework of wood strips should be installed around the stakes at the crest of the overflow area 1.5 feet above the crest of the drop inlet.
- ▲ Excavate a trench of 8 inches to 12 inches in depth around the outside perimeter of the stakes. If a sediment trapping sump is being provided then the excavation may be as deep as 2 feet.
- ▲ Staple the filter fabric to the wooden stakes with heavy-duty staples, overlapping the joints to the next stake. Ensure that between 12 inches to 32 inches of filter fabric extends at the bottom so it can be formed into the trench.
- ▲ Place the bottom of the fabric in the trench and backfill the trench all the way around using washed gravel to a minimum depth of 4 inches.

FILTER FABRIC INLET PROTECTION

Maintenance

- ▲ Inspect regularly and after every storm. Make any repairs necessary to ensure the measure is in good working order.
- ▲ Sediment should be removed and the trap restored to its original dimensions when sediment has accumulated to $\frac{1}{2}$ the design depth of the trap.
- ▲ If the filter fabric becomes clogged it should be replaced immediately.
- ▲ Make sure that the stakes are firmly in the ground and that the filter fabric continues to be securely anchored.
- ▲ All sediments removed should be properly disposed.
- ▲ Inlet protection should remain in place and operational until the drainage area is completely stabilized or up to 30 days after the permanent site stabilization is achieved.

Cost

- ▲ The cost of storm drain inlet protection varies dependent upon the size and type of inlet to be protected but generally is about \$300.00 per inlet.

Sources

- ▲ Commonwealth of Virginia - County of Fairfax, 1987. 1987 Check List For Erosion And Sediment Control - Fairfax County, Virginia.
- ▲ State of North Carolina, 1988. Erosion and Sediment Control Planning and Design Manual. North Carolina Sedimentation Control Commission, Department of Natural Resources and Community Development.
- ▲ Maryland Department of the Environment, 1991. 1991 Maryland Standards And Specifications For Soil Erosion And Sediment Control - Draft.
- ▲ Storm Water Management Manual for the Puget Sound Basin. State of Washington, Department of Ecology, 1991.
- ▲ Cost Data:
 - ▲ Draft Sediment and Erosion Control, An Inventory of Current Practices, April 20, 1990. Prepared by Kamber Engineering for the U.S. Environmental Protection Agency, Office of Water Enforcement and Permits, Washington, D.C. 20460.

EXCAVATED GRAVEL INLET PROTECTION

September 1992

Design Criteria

- ▲ Inlet protection is appropriate in the following locations:
 - ▲ In small drainage areas (less than 1 acre) where the storm drain inlet is functional before the drainage area has been permanently stabilized.
 - ▲ Where there is danger of sediment silting in an inlet which is in place prior to permanent stabilization.
 - ▲ Where ponding around the inlet structure could be a problem to traffic on site.
- ▲ Excavated gravel and mesh inlet protection may be used with most inlets where overflow capability is needed and in areas of heavy flows, 0.5 cfs or greater.
- ▲ The drainage area should not exceed 1 acre.
- ▲ The drainage area should be fairly flat with slopes of 5% or less.
- ▲ The trap should have a sediment trapping sump of 1 to 2 feet measured from the crest of the inlet. Side slopes should be 2:1. The recommended volume of excavation is 35 yd³/acre disturbed.
- ▲ To achieve maximum trapping efficiency the longest dimension of the basin should be oriented toward the longest inflow area.

Materials

- ▲ Hardware cloth or wire mesh with ½ inch openings.
- ▲ Filter fabric (see the fabric specifications for silt fence).
- ▲ Washed gravel ¾ inches to 4 inches in diameter.

Construction Specifications

- ▲ Remove any obstructions to excavating and grading. Excavate sump area, grade slopes and properly dispose of soil.
- ▲ The inlet grate should be secured to prevent seepage of sediment laden water.
- ▲ Place wire mesh over the drop inlet so that the wire extends a minimum of 1 foot beyond each side of the inlet structure. Overlap the strips of mesh if more than one is necessary.
- ▲ Place filter fabric over the mesh extending it at least 18 inches beyond the inlet opening on all sides. Ensure that weep holes in the inlet structure are protected by filter fabric and gravel.
- ▲ Place stone/gravel over the fabric/wire mesh to a depth of at least 1 foot.

EXCAVATED GRAVEL INLET PROTECTION

Maintenance

- ▲ Inspect regularly and after every storm. Make any repairs necessary to ensure the measure is in good working order.
- ▲ Sediment should be removed and the trap restored to its original dimensions when sediment has accumulated to ½ the design depth of the trap.
- ▲ Clean or remove and replace the stone filter or filter fabric if they become clogged.
- ▲ Inlet protection should remain in place and operational until the drainage area is completely stabilized or up to 30 days after the permanent site stabilization is achieved.

Cost

- ▲ The cost of storm drain inlet protection varies dependent upon the size and type of inlet to be protected but generally is about \$300.00 per inlet.

Sources

- ▲ Commonwealth of Virginia - County of Fairfax, 1987. 1987 Check List For Erosion And Sediment Control - Fairfax County, Virginia.
- ▲ State of North Carolina, 1988. Erosion and Sediment Control Planning and Design Manual. North Carolina Sedimentation Control Commission, Department of Natural Resources and Community Development.
- ▲ Maryland Department of the Environment, 1991. 1991 Maryland Standards And Specifications For Soil Erosion And Sediment Control - Draft.
- ▲ Storm Water Management Manual for the Puget Sound Basin. State of Washington, Department of Ecology, 1991.
- ▲ Cost Data:
 - ▲ Draft Sediment and Erosion Control, An Inventory of Current Practices, April 20, 1990. Prepared by Kamber Engineering for the U.S. Environmental Protection Agency, Office of Water Enforcement and Permits, Washington, D.C. 20460.

BLOCK AND GRAVEL INLET PROTECTION

September 1992

Design Criteria

- ▲ Inlet protection is appropriate in the following locations:
 - ▲ In drainage areas (less than 1 acre) where the storm drain inlet is functional before the drainage area has been permanently stabilized.
 - ▲ Where there is danger of sediment silting in an inlet which is in place prior to permanent stabilization.
- ▲ Block and gravel inlet protection may be used with most types of inlets where overflow capability is needed and in areas of heavy flows 0.5 cfs or greater.
- ▲ The drainage area should not exceed 1 acre.
- ▲ The drainage area should be fairly flat with slopes of 5% or less.
- ▲ To achieve maximum trapping efficiency the longest dimension of the basin should be oriented toward the longest inflow area.
- ▲ Where possible the trap should have sediment trapping sump of 1 to 2 feet in depth with side slopes of 2:1.
- ▲ There are several other types of inlet protection also used to prevent siltation of storm drainage systems and structures during construction, they are:
 - ▲ Filter Fabric Inlet Protection
 - ▲ Excavated Gravel Inlet Protection

Materials

- ▲ Hardware cloth or wire mesh with $\frac{1}{2}$ inch openings
- ▲ Filter fabric (see the fabric specifications for silt fence)
- ▲ Concrete block 4 inches to 12 inches wide.
- ▲ Washed gravel $\frac{3}{4}$ inches to 4 inches in diameter

Construction Specifications

- ▲ The inlet grate should be secured to prevent seepage of sediment laden water.
- ▲ Place wire mesh over the drop inlet so that the wire extends a minimum of 12 inches to 18 inches beyond each side of the inlet structure. Overlap the strips of mesh if more than one is necessary.
- ▲ Place filter fabric (optional) over the mesh and extend it at least 18 inches beyond the inlet structure.
- ▲ Place concrete blocks over the filter fabric in a single row lengthwise on their sides along the sides of the inlet. The foundation should be excavated a minimum of 2 inches below the crest of the inlet and the bottom row of blocks should be against the edge of the structure for lateral support.
- ▲ The open ends of the block should face outward not upward and the ends of adjacent blocks should abut. Lay one block on each side of the structure on its side to allow for dewatering of the pool.
- ▲ The block barrier should be at least 12 inches high and may be up to a maximum of 24 inches high and may be from 4 inches to 12 inches in depth depending on the size of block used.
- ▲ Prior to backfilling, place wire mesh over the outside vertical end of the blocks so that stone does not wash down the inlet.
- ▲ Place gravel against the wire mesh to the top of the blocks.

BLOCK AND GRAVEL INLET PROTECTION

Maintenance

- ▲ Inspect regularly and after every storm. Make any repairs necessary to ensure the measure is in good working order.
- ▲ Sediment should be removed and the trap restored to its original dimensions when sediment has accumulated to $\frac{1}{2}$ the design depth of the trap.
- ▲ All sediments removed should be properly disposed of.
- ▲ Inlet protection should remain in place and operational until the drainage area is completely stabilized or up to 30 days after the permanent site stabilization is achieved.

Cost

- ▲ The cost of storm drain inlet protection varies dependent upon the size and type of inlet to be protected but generally is about \$300.00 per inlet.

Sources

- ▲ Commonwealth of Virginia - County of Fairfax, 1987. 1987 Check List For Erosion And Sediment Control - Fairfax County, Virginia.
- ▲ State of North Carolina, 1988. Erosion and Sediment Control Planning and Design Manual. North Carolina Sedimentation Control Commission, Department of Natural Resources and Community Development.
- ▲ Maryland Department of the Environment, 1991. 1991 Maryland Standards And Specifications For Soil Erosion And Sediment Control - Draft.
- ▲ Storm Water Management Manual for the Puget Sound Basin. State of Washington, Department of Ecology, 1991.
- ▲ Cost Data:
 - ▲ Draft Sediment and Erosion Control, An Inventory of Current Practices, April 20, 1990. Prepared by Kamber Engineering for the U.S. Environmental Protection Agency, Office of Water Enforcement and Permits, Washington, D.C. 20460.

TEMPORARY SEDIMENT TRAP

September 1992

Design Criteria

- ▲ Temporary sediment traps are appropriate in the following locations:
 - ▲ At the outlet of the perimeter controls installed during the first stage of construction.
 - ▲ At the outlet of any structure which concentrates sediment-laden runoff, e.g. at the discharge point of diversions, channels, slope drains, or other runoff conveyances.
 - ▲ Above a storm water inlet that is in line to receive sediment-laden runoff.
- ▲ Temporary sediment traps may be constructed by excavation alone or by excavation in combination with an embankment.
- ▲ Temporary sediment traps are often used in conjunction with a diversion dike or swale.
- ▲ The drainage area for the sediment trap should not exceed 5 disturbed acres.
- ▲ The trap must be accessible for ease of regular maintenance which is critical to its functioning properly.
- ▲ Sediment traps are temporary measures and should not be planned to remain in place longer than between 18 and 24 months.
- ▲ The capacity of the sedimentation pool should provide storage volume for 3,600 cubic feet/acre drainage area.
- ▲ The outlet should be designed to provide a 2 foot settling depth and an additional sediment storage area 1 ½ feet deep at the bottom of the trap.
- ▲ The embankment may not exceed 5 feet in height.
- ▲ The recommended minimum width at the top of the embankment is between 2 feet and 5 feet.
- ▲ The minimum recommended length of the weir is between 3 feet and 4 feet, and the maximum is 12 feet in length.
- ▲ Table 5 illustrates the typical relationship between the embankment height, the height of the outlet (H_o), and the width (W) at the top of the embankment.

TABLE 5. EMBANKMENT HEIGHT vs. OUTLET HEIGHT AND WIDTH

| H | H_o | W |
|-----|-------|-----|
| 1.5 | 0.5 | 2.0 |
| 2.0 | 1.0 | 2.0 |
| 2.5 | 1.5 | 2.5 |
| 3.0 | 2.0 | 2.5 |
| 3.5 | 2.5 | 3.0 |
| 4.0 | 3.0 | 3.0 |
| 4.5 | 3.5 | 4.0 |
| 5.0 | 4.0 | 4.5 |

Materials

- ▲ Filter fabric (see fabric requirement for silt fence)
- ▲ Coarse aggregate or riprap 2 inches to 14 inches in diameter
- ▲ Washed gravel ¾ to 1 ½ inches in diameter
- ▲ Seed and mulch for stabilization

TEMPORARY SEDIMENT TRAP

Construction Specifications

- ▲ Clear the area of all trees, brush, stumps or other obstructions.
- ▲ Construct the embankment in 8 inch lifts compacting each lift with the appropriate earth moving equipment. Fill material must be free of woody vegetation, roots, or large stones.
- ▲ Keep cut and fill slopes between 3:1 and 2:1 or flatter.
- ▲ Line the outlet area with filter fabric prior to placing stone or gravel.
- ▲ Construct the gravel outlet using heavy stones between 6 inches and 14 inches in diameter and face the upstream side with a 12 inch layer of $\frac{3}{4}$ inch to $1\frac{1}{2}$ inch washed gravel on the upstream side.
- ▲ Seed and mulch the embankment as soon as possible to ensure stabilization.

Maintenance

- ▲ Inspect regularly and after every storm. Make any repairs necessary to ensure the measure is in good working order.
- ▲ Frequent removal of sediment is critical to the functioning of this measure. At a minimum sediment should be removed and the trap restored to its original volume when sediment reaches $\frac{1}{3}$ of the original volume.
- ▲ Sediment removed from the trap must be properly disposed.
- ▲ Check the embankment regularly to make sure it is structurally sound.

Cost

- ▲ Costs for a sediment trap vary widely based upon their size and the amount of excavation and stone required, they usually can be installed for \$500 to \$7,000.

Sources

- ▲ Commonwealth of Virginia - County of Fairfax, 1987. 1987 Check List For Erosion And Sediment Control - Fairfax County, Virginia.
- ▲ State of North Carolina, 1988. Erosion and Sediment Control Planning and Design Manual. North Carolina Sedimentation Control Commission, Department of Natural Resources and Community Development.
- ▲ Maryland Department of the Environment, 1991. 1991 Maryland Standards And Specifications For Soil Erosion And Sediment Control - Draft.
- ▲ Storm Water Management Manual for the Puget Sound Basin. State of Washington, Department of Ecology, 1991.
- ▲ Cost Data:
 - ▲ Draft Sediment and Erosion Control, An Inventory of Current Practices, April 20, 1990. Prepared by Kamber Engineering for the U.S. Environmental Protection Agency, Office of Water Enforcement and Permits, Washington, D.C. 20460.

APPENDIX F
TESTS FOR NON-STORM WATER DISCHARGES

TESTS FOR NON-STORM WATER DISCHARGES

DYE TESTING

Dye testing can be used to establish positively if certain facilities or fixtures are connected to a storm water collection system. The dye is simply introduced into the suspected waste stream, and storm water outfalls are examined for detections of the dye. Specially manufactured dyes are available for this type of testing. Check with your local sewer authority before conducting this test—dyes can be toxic and thus harmful to the municipal sewage treatment plant

Equipment

Two types of safe and harmless but effective dyes are available for dye testing. Powder in cans or containers is measured by a spoon or small dipper. Tablets of the dye are slower to dissolve than the powder form, but are less messy and are sometimes more desirable than the powder for this reason. The dye is the only piece of equipment needed. Regardless of the type of dye, dissolve it in the flow. A tablet may sink into a sump or wet well and not circulate with the usual flow.

CAUTION: Some dyes may leave a stain if spilled. These stains can be very difficult to remove.

Contact the water pollution control agency to determine if there are any regulations regarding the use of dyes.

Operation

While one operator applies the dye to the suspected location, another operator maintains a watch at the next downstream manhole from the location.

- Where a plumbing fixture is used, such as a water closet bowl or basin, the water is turned on and the dye powder or tablet is dropped directly into the drain.
- Where there is no immediate supply of water, such as a roof gutter or storm drain in dry weather, pouring a bucket of water with the dye powder is suggested. The amount of water and dye needed depends on the distance to the next manhole and the existing flow.
- Based on the assumed velocity of flow, an estimate may be made of the expected flow time to the downstream manhole. Allow plenty of time because the dye often takes much longer than expected.
- Use of powdered dye can be difficult and messy on a windy day. When the wind blows, either pre-mix the dye in water or enclose a quantity of the powder dye in either tissue or toilet paper. Wind can scatter a powdered dye, the dye is impossible to collect. The dye may land on the property of nearby residents and businesses, and when wet, cause stains on buildings, autos, clothes, and landscaping.
- When a number of dye tests are to be conducted on the same line or section of a sewer system, the dye testing should start at the facility farthest downstream and progressively work upstream for the other dye tests. Otherwise, if you dye the facilities upstream first, the flow is then contaminated with dye, and you then must wait several hours or until the next day to conduct additional tests.
- When tests are completed, record whether or not the service is connected to the sewer.

APPENDIX G

COMPARISON OF OTHER ENVIRONMENTAL PLANS

POTENTIALLY RELEVANT ELEMENTS OF OTHER FACILITY ENVIRONMENTAL PLANS

| Required Elements of Each Plan | Storm Water Pollution Prevention Plan | Preparedness Prevention and Contingency Plan (40 CFR 264 and 265) | Spill Control and Countermeasures (40 CFR 112) | NPDES Toxic Organic Management Plan (40 CFR 413, 433, 469) | OSHA Emergency Action Plan (29 CFR 1910) |
|---|--|---|---|---|---|
| Identification of Pollutants of Concern | <ul style="list-style-type: none"> • Description of potential pollutant sources • Risk identification • Material inventory • Test for illicit connections | <ul style="list-style-type: none"> • Requires identification of hazardous wastes handled at the facility and associated hazards | <ul style="list-style-type: none"> • Requires prediction of direction, rate of flow and total quantity of oil that could be discharged | <ul style="list-style-type: none"> • Requires identification of toxic organic compounds used | <ul style="list-style-type: none"> • Requires list of major workplace fire and emergency hazards |
| Coordinator | <ul style="list-style-type: none"> • Pollution prevention planner or team under supervision of plant manager | <ul style="list-style-type: none"> • Emergency coordinator at facility or on call at all times to coordinate emergency response. | <ul style="list-style-type: none"> • Designated person who is accountable for oil spill prevention and who reports to line management | Not specifically addressed | Not specifically addressed |
| Operational Controls | <ul style="list-style-type: none"> • Preventive maintenance program • Good housekeeping • Spill prevention and response procedures • Site-specific storm water BMPs • Activity-specific BMPs | <ul style="list-style-type: none"> • Requires that personnel involved in hazardous waste activities have access to emergency communication device | <ul style="list-style-type: none"> • Requires appropriate spill prevention and containment procedures | <ul style="list-style-type: none"> • Requires method of disposal used instead of dumping into drain be specified • Procedures for assuring that toxic organics do not routinely spill or leak into wastewater | <ul style="list-style-type: none"> • Requires employer to control accumulations of flammable and combustible waste • Maintain equipment and systems to prevent accidental ignition of combustible materials |
| Structural Controls | <ul style="list-style-type: none"> • Sediment and erosion control • Site-specific storm water BMPs • Activity-specific BMPs • BMPs for non-storm water discharges • Enclosure of salt storage piles • <i>Provide containment, drainage control, and/or diversionary structures to prevent contamination of storm water discharges associated with industrial activity from facilities subject to EPCRA Section 313</i> • <i>Security for EPCRA Section 313 facilities</i> | <ul style="list-style-type: none"> • Maintain aisle space for movement of emergency equipment and personnel • Specific requirements for storage tanks | <ul style="list-style-type: none"> • Appropriate containment and/or diversionary structures or equipment (detailed suggestions provided in reg.) • Security - including fences and gates, locks for flow and drain valves and pumps, and lighting | <ul style="list-style-type: none"> • Specify method of disposal used instead of dumping into drain • Procedures for assuring that toxic organics do not routinely spill or leak into wastewater | Not specifically addressed |

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Appendix G

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POTENTIALLY RELEVANT ELEMENTS OF OTHER FACILITY ENVIRONMENTAL PLANS (Continued)

| Required Elements of Each Plan | Storm Water Pollution Prevention Plan | Preparedness Prevention and Contingency Plan (40 CFR 264 and 265) | Spill Control and Countermeasures (40 CFR 112) | NPDES Toxic Organic Management Plan (40 CFR 413, 433, 469) | OSHA Emergency Action Plan (29 CFR 1910) |
|-----------------------------------|--|---|---|--|---|
| Inspections | <ul style="list-style-type: none"> • Routine visual inspection of designated equipment and plant areas, including materials handling, by qualified plant personnel who will also develop procedures to ensure follow up • Annual site inspection to verify the accuracy of pollutant source description, drainage map and controls | Not specifically addressed | <ul style="list-style-type: none"> • Testing and inspection of pollution prevention/control equipment by owner/operator on a scheduled, periodic basis • Inspections should be in accordance with written procedures developed for the facility by the owner/operator | Not specifically addressed | Not specifically addressed |
| Employee Training | <ul style="list-style-type: none"> • Training for employee at all levels in: <ul style="list-style-type: none"> - spill response - good housekeeping - materials management • Specify periodic training dates in plan | Not specifically addressed | <ul style="list-style-type: none"> • Owners/operators are responsible for properly training personnel on applicable regulations and in the operation and maintenance of equipment to prevent discharges • Owners/operators should schedule and conduct spill prevention briefings for operating personnel | Not specifically addressed | <ul style="list-style-type: none"> • Designate and train a sufficient number of persons to assist in safe evacuation |
| Coordinate with Local Authorities | <ul style="list-style-type: none"> • Facilities which discharge storm water to large or medium municipal separate storm sewer systems must comply with applicable conditions in municipal storm water management programs | <ul style="list-style-type: none"> • Familiarize local police and fire departments, hospitals and emergency response teams <ul style="list-style-type: none"> - layout of facility - properties of hazardous wastes - types of injuries • Coordinate arrangements for plan implementation authorities | <ul style="list-style-type: none"> • Follow contingency plan provisions of 40 CFR 109 including consultation with State and local governments | Not specifically addressed | Not specifically addressed |

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Appendix G

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POTENTIALLY RELEVANT ELEMENTS OF OTHER FACILITY ENVIRONMENTAL PLANS (Continued)

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| Required Elements of Each Plan | Storm Water Pollution Prevention Plan | Preparedness Prevention and Contingency Plan (40 CFR 264 and 265) | Spill Control and Countermeasures (40 CFR 112) | NPDES Toxic Organic Management Plan (40 CFR 413, 433, 469) | OSHA Emergency Action Plan (29 CFR 1910) |
|-------------------------------------|---|--|--|--|--|
| Emergency/ Spill Response Equipment | <ul style="list-style-type: none"> • Necessary equipment to implement a spill clean up | <ul style="list-style-type: none"> • List describing emergency equipment and its location: <ul style="list-style-type: none"> - Internal communications (intercom or alarm) - Immediately accessible line of communication to summon emergency assistance (fire/police) - fire extinguishers - water supplies - decontamination equipment - spill control equipment • All equipment must be tested and maintained | <ul style="list-style-type: none"> • Appropriate containment and/or diversionary structures or equipment • If impractical, a written commitment of equipment and materials required to expeditiously control and remove any harmful quantities of oil discharged | Not specifically addressed | <ul style="list-style-type: none"> • Alarm system |

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POTENTIALLY RELEVANT ELEMENTS OF OTHER FACILITY ENVIRONMENTAL PLANS (Continued)

| Required Elements of Each Plan | Storm Water Pollution Prevention Plan | Preparedness Prevention and Contingency Plan (40 CFR 264 and 265) | Spill Control and Countermeasures (40 CFR 112) | NPDES Toxic Organic Management Plan (40 CFR 413, 433, 469) | OSHA Emergency Action Plan (29 CFR 1910) |
|--|---|---|--|--|--|
| Notification/Record Keeping Procedures | <ul style="list-style-type: none"> • Record spills and other discharges • Record storm water quality/ quantity information • Document inspection and maintenance activities • Certify that discharge has been tested for the presence of non-storm water discharges or certify where such testing is not feasible | <ul style="list-style-type: none"> • In case of imminent or actual emergency situation: <ul style="list-style-type: none"> - activate alarms/ communication systems to notify facility personnel - notify State/local agencies - identify the character, exact source, amount and areal extent of release - assess hazards to human health and the environment and respond - facilitate containment - coordinate clean up - submit incident report | <ul style="list-style-type: none"> • Written procedures for and records of inspections should be made part of the SPCC and maintained for 3 years • Detailed notification requirements apply if a facility has a single spill event of more than 1000 gallons of oil or has discharged oil in harmful quantities in two spill events within the last 12 months | Not specifically addressed | <ul style="list-style-type: none"> • Means of reporting fires and other emergencies |
| Evacuation Procedures | Not specifically addressed | <ul style="list-style-type: none"> • Evacuation plan describing: <ul style="list-style-type: none"> - signals to begin evacuation - primary and alternate routes | Not specifically addressed | Not specifically addressed | <ul style="list-style-type: none"> • Emergency escape routes • Procedures to account for all employees • Procedures for employees who remain behind to perform critical functions |

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Appendix G

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POTENTIALLY RELEVANT ELEMENTS OF OTHER FACILITY ENVIRONMENTAL PLANS (Continued)

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| Required Elements of Each Plan | Storm Water Pollution Prevention Plan | Preparedness Prevention and Contingency Plan (40 CFR 264 and 265) | Spill Control and Countermeasures (40 CFR 112) | NPDES Toxic Organic Management Plan (40 CFR 413, 433, 469) | OSHA Emergency Action Plan (29 CFR 1910) |
|--------------------------------|--|--|--|--|--|
| Plan Location/ Distribution | <ul style="list-style-type: none"> • Maintained at facility unless requested by the director or the municipal operator | <ul style="list-style-type: none"> • Maintained at facility • Submitted to local police, fire, hospital, and State and local emergency response teams | <ul style="list-style-type: none"> • Maintain at facility if facility is normally attended at least 8 hours per day or at nearest field office if not so attended | <ul style="list-style-type: none"> • Submitted to permitting authority for approval | <ul style="list-style-type: none"> • Plan shall be written and kept at the workplace unless there are fewer than 10 employees, then oral communication is sufficient • Employer shall review the plan with each employee covered by the plan when: <ul style="list-style-type: none"> - Plan is initially developed - Plan changes - Employee's responsibility changes |
| Modification of Plan | <ul style="list-style-type: none"> • Plan fails to control pollutants in storm water • Change in design, construction, operation or maintenance • Requested by the director | <ul style="list-style-type: none"> • Facility permit revised • Plan fails during emergency • Facility changes • Emergency coordinator(s) change • Emergency equipment changes | <ul style="list-style-type: none"> • By the Regional Administrator where the plan does not meet requirements or is necessary to prevent and contain discharges of oil • By the owner/operator: <ul style="list-style-type: none"> - change in facility - if warranted by findings of 3 years evaluation | Not specifically addressed | Not specifically addressed |

POTENTIALLY RELEVANT ELEMENTS OF OTHER FACILITY ENVIRONMENTAL PLANS (Continued)

| Required Elements of Each Plan | Storm Water Pollution Prevention Plan | Preparedness Prevention and Contingency Plan (40 CFR 264 and 265) | Spill Control and Countermeasures (40 CFR 112) | NPDES Toxic Organic Management Plan (40 CFR 413, 433, 469) | OSHA Emergency Action Plan (29 CFR 1910) |
|--------------------------------|--|---|---|---|--|
| Certification | <ul style="list-style-type: none"> • Certify that discharges have been tested for the presence of non-storm water discharges • Plans must be signed and certified in accordance with 40 CFR 122.22 • <i>Spill prevention and response plan for facilities subject to EPCRA Section 313 must be reviewed and certified every three years by a registered professional engineer</i> | Not specifically addressed | <ul style="list-style-type: none"> • Plan must be reviewed and certified by a registered professional engineer | No dumping of toxic organic compounds into the wastewater has occurred and the approved TOMP is being implemented | Not specifically addressed |

APPENDIX H

LIST OF HAZARDOUS SUBSTANCES AND REPORTABLE QUANTITIES

LIST OF HAZARDOUS SUBSTANCES AND REPORTABLE QUANTITIES
40 CFR 302.4 and 117

Note: All comments are located at the end of this table.

| Hazardous Substance | CASRN | Regulatory Synonyms | Statutory | | | Final RQ | |
|---------------------------------------|--------|--|-----------|-------|--------------|-----------|-------------|
| | | | RQ | Code† | RCRA Waste # | Cate-gory | Pounds (Kg) |
| Acenaphthene | 83329 | | 1* | 2 | | B | 100 (45.4) |
| Acenaphthylene | 208968 | | 1* | 2 | | D | 5000 (2270) |
| Acetaldehyde | 75070 | Ethanal | 1000 | 1,4 | U001 | C | 1000 (454) |
| Acetaldehyde, chloro- | 107200 | Chloroacetaldehyde | 1* | 4 | P023 | C | 1000 (454) |
| Acetaldehyde, trichloro- | 75876 | Chloral | 1* | 4 | U034 | D | 5000 (2270) |
| Acetamide, N-(aminothioxomethyl)- | 591082 | 1-Acetyl-2-thiourea | 1* | 4 | P002 | C | 1000 (454) |
| Acetamide, N-(4-ethoxyphenyl)- | 62442 | Phenacetin | 1* | 4 | U187 | B | 100 (45.4) |
| Acetamide, 2-fluoro- | 640197 | Fluoroacetamide | 1* | 4 | P057 | B | 100 (45.4) |
| Acetamide, N-9H-fluoren-2-yl- | 53963 | 2-Acetylaminofluorene | 1* | 4 | U005 | X | 1 (0.454) |
| Acetic acid | 64197 | | 1000 | 1 | | D | 5000 (2270) |
| Acetic acid (2,4-dichlorophenoxy)- | 94757 | 2,4-D Acid 2,4-D, salts and esters | 100 | 1,4 | U240 | B | 100 (45.4) |
| Acetic Acid, lead(2+) salt | 301042 | Lead acetate | 5000 | 1,4 | U144 | | # |
| Acetic acid, thallium(1+) salt | 563688 | Thallium(I) acetate | 1* | 4 | U214 | B | 100 (45.4) |
| Acetic acid (2,4,5-trichlorophenoxy)- | 93765 | 2,4,5-T 2,4,5-T acid | 100 | 1,4 | U232 | C | 1000 (454) |
| Acetic acid, ethyl ester | 141786 | Ethyl acetate | 1* | 4 | U112 | D | 5000 (2270) |
| Acetic acid, fluoro-, sodium salt | 62748 | Fluoroacetic acid, sodium salt | 1* | 4 | P058 | A | 10 (4.54) |
| Acetic anhydride | 108247 | | 1000 | 1 | | D | 5000 (2270) |
| Acetone | 67641 | 2-Propanone | 1* | 4 | U002 | D | 5000 (2270) |
| Acetone cyanohydrin | 75865 | Propanenitrile, 2-hydroxy-2-methyl-2-Methylactonitrile | 10 | 1,4 | P069 | A | 10 (4.54) |
| Acetonitrile | 75058 | | 1* | 4 | U003 | D | 5000 (2270) |
| Acetophenone | 98862 | Ethanone, 1-phenyl- | 1* | 4 | U004 | D | 5000 (2270) |
| 2-Acetylaminofluorene | 53963 | Acetamide, N-9H-fluoren-2-yl- | 1* | 4 | U005 | X | 1 (0.454) |
| Acetyl bromide | 506967 | | 5000 | 1 | | D | 5000 (2270) |
| Acetyl chloride | 75365 | | 5000 | 1,4 | U006 | D | 5000 (2270) |
| 1-Acetyl-2-thiourea | 591082 | Acetamide, N-(aminothioxomethyl)- | 1* | 4 | P002 | C | 1000 (454) |
| Acrolein | 107028 | 2-Propenal | 1 | 1,2,4 | P003 | X | 1 (0.454) |
| Acrylamide | 79061 | 2-Propenamide | 1* | 4 | U007 | D | 5000 (2270) |

| Hazardous Substance | CASRN | Regulatory Synonyms | Statutory | | | Final RQ | |
|------------------------------|----------|---|-----------|-------|--------------|-----------|-------------|
| | | | RQ | Code† | RCRA Waste # | Cate-gory | Pounds (Kg) |
| Acrylic acid | 79107 | 2-Propenoic acid | 1* | 4 | U008 | D | 5000 (2270) |
| Acrylonitrile | 107131 | 2-Propenenitrile | 100 | 1,2,4 | U009 | B | 100 (45.4) |
| Adipic acid | 124049 | | 5000 | 1 | | D | 5000 (2270) |
| Aldicarb | 116063 | Propanal, 2-methyl-2-(methylthio)-,O-[(methylamino) carbonyl]oxime | 1* | 4 | P070 | X | 1 (0.454) |
| Aldrin | 309002 | 1,4,5,8-Dimethanonaphthalene, 1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-, (1alpha,4alpha,4abeta,5alpha,8alpha,8abeta)- | 1 | 1,2,4 | P004 | X | 1 (0.454) |
| Allyl alcohol | 107186 | 2-Propen-1-ol | 100 | 1,4 | P005 | B | 100 (45.4) |
| Allyl chloride | 107051 | | 1000 | 1 | | C | 1000 (454) |
| Aluminum phosphide | 20859738 | | 1* | 4 | P006 | B | 100 (45.4) |
| Aluminum sulfate | 10043013 | | 5000 | 1 | | D | 5000 (2270) |
| 5-(Aminomethyl)-3-isoxazolol | 2763964 | Muscimol 3(2H)-isoxazolone, 5-(aminomethyl)- | 1* | 4 | P007 | C | 1000 (454) |
| 4-Aminopyridine | 504245 | 4-Pyridinamine | 1* | 4 | P008 | C | 1000 (454) |
| Amitrole | 61825 | 1H-1,2,4-Triazol-3-amine | 1* | 4 | U011 | A | 10 (4.54) |
| Ammonia | 7664417 | | 100 | 1 | | B | 100 (45.4) |
| Ammonium acetate | 631618 | | 5000 | 1 | | D | 5000 (2270) |
| Ammonium benzoate | 1863634 | | 5000 | 1 | | D | 5000 (2270) |
| Ammonium bicarbonate | 1066337 | | 5000 | 1 | | D | 5000 (2270) |
| Ammonium bichromate | 7789095 | | 1000 | 1 | | A | 10 (4.54) |
| Ammonium bifluoride | 1341497 | | 5000 | 1 | | B | 100 (45.4) |
| Ammonium bisulfite | 10192300 | | 5000 | 1 | | D | 5000 (2270) |
| Ammonium carbamate | 1111780 | | 5000 | 1 | | D | 5000 (2270) |
| Ammonium carbonate | 506876 | | 5000 | 1 | | D | 5000 (2270) |
| Ammonium chloride | 12125029 | | 5000 | 1 | | D | 5000 (2270) |
| Ammonium chromate | 7788989 | | 1000 | 1 | | A | 10 (4.54) |
| Ammonium citrate, dibasic | 3012655 | | 5000 | 1 | | D | 5000 (2270) |
| Ammonium fluoborate | 13826830 | | 5000 | 1 | | D | 5000 (2270) |
| Ammonium fluoride | 12125018 | | 5000 | 1 | | B | 100 (45.4) |
| Ammonium hydroxide | 1336216 | | 1000 | 1 | | C | 1000 (454) |
| Ammonium oxalate | 6009707 | | 5000 | 1 | | D | 5000 (2270) |

| Hazardous Substance | CASRN | Regulatory Synonyms | Statutory | | | Final RQ | |
|---|----------|--|-----------|-------|--------------|----------|-------------|
| | | | RQ | Code† | RCRA Waste # | Category | Pounds (Kg) |
| | 5972736 | | 5000 | 1 | | D | 5000 (2270) |
| | 14258492 | | 5000 | 1 | | D | 5000 (2270) |
| Ammonium picrate | 131748 | Phenol, 2,4,6-trinitro-, ammonium salt | 1* | 4 | P009 | A | 10 (4.54) |
| Ammonium silicofluoride | 16919190 | | 1000 | 1 | | C | 1000 (454) |
| Ammonium sulfamate | 7773060 | | 5000 | 1 | | D | 5000 (2270) |
| Ammonium sulfide | 12135761 | | 5000 | 1 | | B | 100 (45.4) |
| Ammonium sulfite | 10196040 | | 5000 | 1 | | D | 5000 (2270) |
| Ammonium tartrate | 14307438 | | 5000 | 1 | | D | 5000 (2270) |
| | 3164292 | | 5000 | 1 | | D | 5000 (2270) |
| Ammonium thiocyanate | 1762954 | | 5000 | 1 | | D | 5000 (2270) |
| Ammonium vanadate | 7803556 | Vanadic acid, ammonium salt | 1* | 4 | P119 | C | 1000 (454) |
| Amyl acetate | 628637 | | 1000 | 1 | | D | 5000 (2270) |
| iso-Amyl acetate | 123922 | | 1000 | 1 | | D | 5000 (2270) |
| sec-Amyl acetate | 626380 | | 1000 | 1 | | D | 5000 (2270) |
| tert-Amyl acetate | 625161 | | 1000 | 1 | | D | 5000 (2270) |
| Aniline | 62533 | Benzenamine | 1000 | 1,4 | U012 | D | 5000 (2270) |
| Anthracene | 120127 | | 1* | 2 | | D | 5000 (2270) |
| Antimony†† | 7440360 | | 1* | 2 | | D | 5000 (2270) |
| ANTIMONY AND COMPOUNDS | N/A | | 1* | 2 | | | ** |
| Antimony pentachloride | 7647189 | | 1000 | 1 | | C | 1000 (454) |
| Antimony potassium tartrate | 28300745 | | 1000 | 1 | | B | 100 (45.4) |
| Antimony tribromide | 7789619 | | 1000 | 1 | | C | 1000 (454) |
| Antimony trichloride | 10025919 | | 1000 | 1 | | C | 1000 (454) |
| Antimony trifluoride | 7783564 | | 1000 | 1 | | C | 1000 (454) |
| Antimony trioxide | 1309644 | | 5000 | 1 | | C | 1000 (454) |
| Argentate(1-), bis(cyano-C)-, potassium | 506616 | Potassium silver cyanide | 1* | 4 | P099 | X | 1 (0.454) |
| Aroclor 1016 | 12674112 | POLYCHLORINATED BIPHENYLS (PCBs) | 10 | 1,2 | | X | 1 (0.454) |
| Aroclor 1221 | 11104282 | POLYCHLORINATED BIPHENYLS (PCBs) | 10 | 1,2 | | X | 1 (0.454) |
| Aroclor 1232 | 11141165 | POLYCHLORINATED BIPHENYLS (PCBs) | 10 | 1,2 | | X | 1 (0.454) |

| Hazardous Substance | CASRN | Regulatory Synonyms | Statutory | | | Final RQ | |
|---|----------|---|-----------|-------|--------------|-----------|-------------|
| | | | RQ | Code† | RCRA Waste # | Cate-gory | Pounds (Kg) |
| Aroclor 1242 | 53469219 | POLYCHLORINATED BIPHENYLS (PCBs) | 10 | 1,2 | | X | 1 (0.454) |
| Aroclor 1248 | 12672296 | POLYCHLORINATED BIPHENYLS (PCBs) | 10 | 1,2 | | X | 1 (0.454) |
| Aroclor 1254 | 11097691 | POLYCHLORINATED BIPHENYLS (PCBs) | 10 | 1,2 | | X | 1 (0.454) |
| Aroclor 1260 | 11096825 | POLYCHLORINATED BIPHENYLS (PCBs) | 10 | 1,2 | | X | 1 (0.454) |
| Arsenic†† | 7440382 | | 1* | 2,3 | | X | 1 (0.454) |
| Arsenic acid | 1327522 | Arsenic acid H3AsO4 | 1* | 4 | P010 | X | 1 (0.454) |
| | 7778394 | | | | | | |
| Arsenic acid H3AsO4 | 1327522 | Arsenic acid | 1* | 4 | P010 | X | 1 (0.454) |
| | 7778394 | | 1* | 4 | P010 | X | 1(0.454) |
| ARSENIC AND COMPOUNDS | N/A | | 1* | 2 | | | ** |
| Arsenic disulfide | 1303328 | | 5000 | 1 | | X | 1 (0.454) |
| Arsenic oxide As2O3 | 1327533 | Arsenic trioxide | 5000 | 1,4 | P012 | X | 1 (0.454) |
| Arsenic oxide As2O5 | 1303282 | Arsenic pentoxide | 5000 | 1,4 | P011 | X | 1 (0.454) |
| Arsenic pentoxide | 1303282 | Arsenic oxide As2O5 | 5000 | 1,4 | P011 | X | 1 (0.454) |
| Arsenic trichloride | 7784341 | | 5000 | 1 | | X | 1 (0.454) |
| Arsenic trioxide | 1327533 | Arsenic oxide As2O3 | 5000 | 1,4 | P012 | X | 1 (0.454) |
| Arsenic trisulfide | 1303339 | | 5000 | 1 | | X | 1 (0.454) |
| Arsine, diethyl- | 692422 | Diethylarsine | 1* | 4 | P038 | X | 1 (0.454) |
| Arsinic acid, dimethyl- | 75605 | Cacodylic acid | 1* | 4 | U136 | X | 1 (0.454) |
| Arsinous dichloride, phenyl- | 696286 | Dichlorophenylarsine | 1* | 4 | P036 | X | 1 (0.454) |
| Asbestos††† | 1332214 | | 1* | 2,3 | | X | 1 (0.454) |
| Auramine | 492808 | Benzenamine, 4,4'-carbonimidoylbis (N,N-dimethyl- | 1* | 4 | U014 | B | 100 (45.4) |
| Azaserine | 115026 | L-Serine, diazoacetate (ester) | 1* | 4 | U015 | X | 1 (0.454) |
| Aziridine | 151564 | Ethylenimine | 1* | 4 | P054 | X | 1 (0.454) |
| Aziridine, 2-methyl- | 75558 | 1,2-Propylenimine | 1* | 4 | P067 | X | 1 (0.454) |
| Azirino[2',3':3,4]pyrrolo[1,2-a]indole-4,7-dione,6-amino-8-[[[(aminocarbonyloxy)methyl]-1,1a,2,8,8a,8b-hexahydro-8a-methoxy-5-methyl-,[1aS-(1aalpha,8beta,8alpha,8beta)]- | 50077 | Mitomycin C | 1* | 4 | U010 | A | 10 (4.54) |

| Hazardous Substance | CASRN | Regulatory Synonyms | Statutory | | | Final RQ | |
|---|----------|--|-----------|-------------|--------------|----------|-------------|
| | | | RQ | Code† | RCRA Waste # | Category | Pounds (Kg) |
| Barium cyanide | 542621 | | 10 | 1,4 | P013 | A | 10 (4.54) |
| Benz[j]aceanthrylene, 1,2-dihydro-3-methyl- | 56495 | 3-Methylcholanthrene | 1* | 4 | U157 | A | 10 (4.54) |
| Benz(c)acridine | 225514 | | 1* | 4 | U016 | B | 100 (45.4) |
| Benzal chloride | 98873 | Benzene, dichloromethyl- | 1* | 4 | U017 | D | 5000 (2270) |
| Benzamide, 3,5-dichloro-N-(1,1-dimethyl-2-propynyl)- | 23950585 | Pronamide | 1* | 4 | U192 | D | 5000 (2270) |
| Benz[a]anthracene | 56553 | Benzo[a]anthracene 1,2-Benzanthracene | 1* | 2,4 | U018 | A | 10 (4.54) |
| 1,2-Benzanthracene | 56553 | Benzo[a]anthracene Benzo[a]anthracene | 1* | 2,4 | U018 | A | 10 (4.54) |
| Benz[a]anthracene, 7,12-dimethyl- | 57976 | 7,12-Dimethylbenzo[a]anthracene | 1* | 4 | U094 | X | 1 (0.454) |
| Benzenamine | 62533 | Aniline | 1000 | 1,4 | U012 | D | 5000 (2270) |
| Benzenamine, 4,4'-carbonimidoylbis (N,N-dimethyl- | 492808 | Auramine | 1* | 4 | U014 | B | 100 (45.4) |
| Benzenamine, 4-chloro- | 106478 | p-Chloroaniline' | 1* | 4 | P024 | C | 1000 (454) |
| Benzenamine, 4-chloro-2-methyl-, hydrochloride | 3165933 | 4-Chloro-o-toluidine, hydrochloride | 1* | 4 | U049 | B | 100 (45.4) |
| Benzenamine, N,N-dimethyl-4(phenylazo-) | 60117 | p-Dimethylaminoazobenzene | 1* | 4 | U093 | A | 10 (4.54) |
| Benzenamine, 2-methyl- | 95534 | o-Toluidine | 1* | 4 | U328 | B | 100 (45.4) |
| Benzenamine, 4-methyl- | 106490 | p-Toluidine | 1* | 4 | U353 | B | 100 (45.4) |
| Benzenamine, 4,4'-methylenebis(2-chloro- | 101144 | 4,4'-Methylenebis(2-chloroaniline) | 1* | 4 | U158 | A | 10 (4.54) |
| Benzenamine, 2-methyl-, hydrochloride | 636215 | o-Toluidine hydrochloride | 1* | 4 | U222 | B | 100 (45.4) |
| Benzenamine, 2-methyl-5-nitro | 99558 | 5-Nitro-o-toluidine | 1* | 4 | U181 | B | 100 (45.4) |
| Benzenamine, 4-nitro- | 100016 | p-Nitroaniline | 1* | 4 | P077 | D | 5000 (2270) |
| Benzene | 71432 | | 1000 | 1,2, 3,4 | U109 | A | 10 (4.54) |
| Benzeneacetic acid, 4-chloro-alpha-(4-chlorophenyl)-alpha-hydroxy-, ethyl ester | 510156 | Chlorobenzilate | 1* | 4 | U038 | A | 10 (4.54) |
| Benzene, 1-bromo-4-phenoxy- | 101553 | 4-Bromophenyl phenyl ether | 1* | 2,4 | U030 | B | 100 (45.4) |
| Benzenebutanoic acid, 4-[bis(2-chloroethyl)amino]- | 305033 | Chlorambucil | 1* | 4 | U035 | A | 10 (4.54) |
| Benzene, chloro- | 108907 | Chlorobenzene | 100 | 1,2,4 | U037 | B | 100 (45.4) |
| Benzene, chloromethyl- | 100447 | Benzyl chloride | 100 | 1,4 | P028 | B | 100 (45.4) |

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| | | | RQ | Code† | RCRA Waste # | Category | Pounds (Kg) |
| Benzenediamin, ar-methyl- | 95807 | Toluenediamine | 1* | 4 | U221 | A | 10 (4.54) |
| | 496720 | | 1* | 4 | U221 | A | 10 (4.54) |
| | 823405 | | 1* | 4 | U221 | A | 10 (4.54) |
| 1,2-Benzenedicarboxylic acid, dioctyl ester | 117840 | Di-n-octyl phthalate | 1* | 2,4 | U107 | D | 5000 (2270) |
| 1,2-Benzenedicarboxylic acid, [bis(2-ethylhexyl)]-ester | 117817 | Bis (2-ethylhexyl)phthalate Diethylhexyl phthalate | 1* | 2,4 | U028 | B | 100 (45.4) |
| 1,2-Benzenedicarboxylic acid, dibutyl ester | 84742 | Di-n-butyl phthalate Dibutyl phthalate n-Butyl phthalate | 100 | 1,2,4 | U069 | A | 10 (4.54) |
| 1,2-Benzenedicarboxylic acid, diethyl ester | 84662 | Diethyl phthalate | 1* | 2,4 | U088 | C | 1000 (454) |
| 1,2-Benzenedicarboxylic acid, dimethyl ester | 131113 | Dimethyl phthalate | 1* | 2,4 | U102 | D | 5000 (2270) |
| Benzene, 1,2-dichloro- | 95501 | o-Dichlorobenzene 1,2-Dichlorobenzene | 100 | 1,2,4 | U070 | B | 100 (45.4) |
| Benzene, 1,3-dichloro- | 541731 | m-Dichlorobenzene 1,3-Dichlorobenzene | 1* | 2,4 | U071 | B | 100 (45.4) |
| Benzene, 1,4-dichloro- | 106467 | p-Dichlorobenzene 1,4-Dichlorobenzene | 100 | 1,2,4 | U072 | B | 100 (45.4) |
| Benzene, 1,1'-(2,2-dichloroethylidene)bis[4-chloro- | 72548 | DDD TDE 4,4' DDD | 1 | 1,2,4 | U060 | X | 1 (0.454) |
| Benzene, dichloromethyl- | 98873 | Benzal chloride | 1* | 4 | U017 | D | 5000 (2270) |
| Benzene, 1,3-diisocyanatomethyl- | 584849 | Toluene diisocyanate | 1* | 4 | U223 | B | 100 (45.4) |
| | 91087 | | 1* | 4 | U223 | B | 100 (45.4) |
| | 26471625 | | 1* | 4 | U223 | B | 100 (45.4) |
| Benzene, dimethyl | 1330207 | Xylene (mixed) | 1000 | 1,4 | U239 | C | 1000 (454) |
| m-Benzene, dimethyl | 108383 | m-Xylene | 1000 | 1,4 | U239 | C | 1000 (454) |
| o-Benzene, dimethyl | 95476 | o-Xylene | 1000 | 1,4 | U239 | C | 1000 (454) |
| p-Benzene, dimethyl | 106423 | p-Xylene | 1000 | 1,4 | U239 | C | 1000 (454) |
| 1,3-Benzenediol | 108463 | Resorcinol | 1000 | 1,4 | U201 | D | 5000 (2270) |
| 1,2-Benzenediol,4-[1-hydroxy-2-(methylamino)ethyl]- | 51434 | Epinephrine | 1* | 4 | P042 | C | 1000 (454) |
| Benzeneethanamine, alpha,alpha-dimethyl- | 122098 | alpha,alpha-Dimethylphenethylamine | 1* | 4 | P046 | D | 5000 (2270) |
| Benzene, hexachloro- | 118741 | Hexachlorobenzene | 1* | 2,4 | U127 | A | 10 (4.54) |
| Benzene, hexahydro- | 110827 | Cyclohexane | 1000 | 1,4 | U056 | C | 1000 (454) |

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| | | | RQ | Code† | RCRA Waste # | Category | Pounds (Kg) |
| Benzene, hydroxy- | 108952 | Phenol | 1000 | 1,2,4 | U188 | C | 1000 (454) |
| Benzene, methyl- | 108883 | Toluene | 1000 | 1,2,4 | U220 | C | 1000 (454) |
| Benzene, 2-methyl-1,3-dinitro- | 606202 | 2,6-Dinitrotoluene | 1000 | 1,2,4 | U106 | B | 100 (45.4) |
| Benzene, 1-methyl-2,4-dinitro- | 121142 | 2,4-Dinitrotoluene | 1000 | 1,2,4 | U105 | A | 10 (4.54) |
| Benzene, 1-methylethyl- | 98828 | Cumene | 1* | 4 | U055 | D | 5000 (2270) |
| Benzene, nitro- | 98953 | Nitrobenzene | 1000 | 1,2,4 | U169 | C | 1000 (454) |
| Benzene, pentachloro- | 608935 | Pentachlorobenzene | 1* | 4 | U183 | A | 10 (4.54) |
| Benzene, pentachloronitro- | 82688 | Pentachloronitrobenzene (PCNB) | 1* | 4 | U185 | B | 100 (45.4) |
| Benzenesulfonic acid chloride | 98099 | Benzenesulfonyl chloride | 1* | 4 | U020 | B | 100 (45.4) |
| Benzenesulfonyl chloride | 98099 | Benzenesulfonic acid chloride | 1* | 4 | U020 | B | 100 (45.4) |
| Benzene, 1,2,4,5-tetrachloro- | 95943 | 1,2,4,5-Tetrachlorobenzene | 1* | 4 | U207 | D | 5000 (2270) |
| Benzenethiol | 108985 | Thiophenol | 1* | 4 | P014 | B | 100 (45.4) |
| Benzene, 1,1'-(2,2,2-trichloroethylidene)bis[4-chloro- | 50293 | DDT 4,4'DDT | 1 | 1,2,4 | U061 | X | 1 (0.454) |
| Benzene, 1,1'-(trichloroethylidene)bis[4-methoxy- | 72435 | Methoxychlor | 1 | 1,4 | U247 | X | 1 (0.454) |
| Benzene, (trichloromethyl)- | 98077 | Benzotrichloride | 1* | 4 | U023 | A | 10 (4.54) |
| Benzene, 1,3,5-trinitro- | 99354 | 1,3,5-Trinitrobenzene | 1* | 4 | U234 | A | 10 (4.554) |
| Benzidine | 92875 | (1,1'-Biphenyl)-4,4'diamine | 1* | 2,4 | U021 | X | 1 (0.454) |
| 1,2-Benzisothiazol-3(2H)-one, 1,1-dioxide | 81072 | Saccharin and salts | 1* | 4 | U202 | B | 100 (45.4) |
| Benzo[a]anthracene | 56553 | Benzo[a]anthracene 1,2-Benzanthracene | 1* | 2,4 | U018 | A | 10 (4.54) |
| Benzo[b]fluoranthene | 205992 | | 1* | 2 | | X | 1 (0.454) |
| Benzo[k]fluoranthene | 207089 | | 1* | 2 | | D | 5000 (2270) |
| Benzo[j,k]fluorene | 206440 | Fluoranthene | 1* | 2,4 | U120 | B | 100 (45.4) |
| 1,3-Benzodioxole, 5-(1-propenyl)- | 120581 | Isosafrole | 1* | 4 | U141 | B | 100 (45.4) |
| 1,3-Benzodioxole, 5-(2-propenyl)- | 94597 | Safrole | 1* | 4 | U203 | B | 100 (45.4) |
| 1,3-Benzodioxole, 5-propyl- | 94586 | Dihydrosafrole | 1* | 4 | U090 | A | 10 (4.54) |
| Benzoic acid | 65850 | | 5000 | 1 | | D | 5000 (2270) |
| Benzonitrile | 100470 | | 1000 | 1 | | D | 5000 (2270) |
| Benzo[rs]pentaphene | 189559 | Dibenz[a,i]pyrene | 1* | 4 | U064 | A | 10 (4.54) |
| Benzo[ghi]perylene | 191242 | | 1* | 2 | | D | 5000 (2270) |

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| 2H-1 Benzopyran-2-one, 4-hydroxy-3-(3-oxo-1-phenyl-butyl)-, & salts, when present at concentrations greater than 0.3% | 81812 | Warfarin, & salts, when present at concentrations greater than 0.3% | 1* | 4 | P001 | B | 100 (45.4) |
| Benzo[a]pyrene | 50328 | 3,4-Benzopyrene | 1* | 2,4 | U022 | X | 1 (0.454) |
| 3,4-Benzopyrene | 50328 | Benzo[a]pyrene | 1* | 2,4 | U022 | X | 1 (0.454) |
| p-Benzoquinone | 106514 | 2,5-Cyclohexadiene-1,4-dione | 1* | 4 | U197 | A | 10 (4.54) |
| Benzotrichloride | 98077 | Benzene, (trichloromethyl)- | 1* | 4 | U023 | A | 10 (4.54) |
| Benzoyl chloride | 98884 | | 1000 | 1 | | C | 1000 (454) |
| 1,2-Benzphenanthrene | 218019 | Chrysene | 1* | 2,4 | U050 | B | 100 (45.4) |
| Benzyl chloride | 100447 | Benzene, chloromethyl- | 100 | 1,4 | P028 | B | 100 (45.4) |
| Beryllium†† | 7440417 | Beryllium dust †† | 1* | 2,3,4 | PO15 | A | 10 (4.54) |
| BERYLLIUM AND COMPOUNDS | N/A | | 1* | 2 | | | ** |
| Beryllium chloride | 7787475 | | 5000 | 1 | | X | 1 (0.454) |
| Beryllium dust†† | 7440417 | Beryllium†† | 1* | 2,3,4 | PO15 | A | 10 (4.54) |
| Beryllium fluoride | 7787497 | | 5000 | 1 | | X | 1 (0.454) |
| Beryllium nitrate | 13597994 | | 5000 | 1 | | X | 1 (0.454) |
| | 7787555 | | 5000 | 1 | | X | 1 (0.454) |
| alpha-BHC | 319846 | | 1* | 2 | | A | 10 (4.54) |
| beta-BHC | 319857 | | 1* | 2 | | X | 1 (0.454) |
| delta-BHC | 319868 | | 1* | 2 | | X | 1 (0.454) |
| gamma-BHC | 58899 | Cyclohexane, 1,2,3,4,5,6-hexachloro-, (1alpha,2alpha,3beta,4alpha,5alpha,6 beta)-Hexachlorocyclohexane (gamma isomer) Lindane | 1 | 1,2,4 | U129 | X | 1 (0.454) |
| 2,2'-Bioxirane | 1464535 | 1,2:3,4-Diepoxybutane | 1* | 4 | U085 | A | 10 (4.54) |
| (1,1'-Biphenyl)-4,4'-diamine | 92875 | Benzidine | 1* | 2,4 | U021 | X | 1 (0.454) |
| [1,1'-Biphenyl]-4,4'-diamine,3,3'-dichloro- | 91941 | 3,3'-Dichlorobenzidine | 1* | 2,4 | U073 | X | 1 (0.454) |
| [1,1'-Biphenyl]-4,4'-diamine,3,3'-dimethoxy- | 119904 | 3,3'-Dimethoxybenzidine | 1* | 4 | U091 | B | 100 (45.4) |
| [1,1'-Biphenyl]-4,4'-diamine,3,3'-dimethyl- | 119937 | 3,3'-Dimethylbenzidine | 1* | 4 | U095 | A | 10 (4.54) |

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| Bis (2-chloroethyl) ether | 111444 | Dichloroethyl ether Ethane, 1,1'-oxybis[2-chloro- | 1* | 2,4 | U025 | A | 10 (4.54) |
| Bis(2-chloroethoxy) methane | 111911 | Dichloromethoxy ethane Ethane, 1,1'-[methylenebis(oxy)] bis(2-chloro- | 1* | 2,4 | U024 | C | 1000 (454) |
| Bis (2-ethylhexyl)phthalate | 117817 | Diethylhexyl phthalate 1,2-Benzenedicarboxylic acid, [bis(2-ethylhexyl)] ester | 1* | 2,4 | U028 | B | 100 (45.4) |
| Bromoacetone | 598312 | 2-Propanone, 1-bromo- | 1* | 4 | P017 | C | 1000 (454) |
| Bromoform | 75252 | Methane, tribromo | 1* | 2,4 | U225 | B | 100 (45.4) |
| 4-Bromophenyl phenyl ether | 101553 | Benzene, 1-bromo-4-phenoxy- | 1* | 2,4 | U030 | B | 100 (45.4) |
| Brucine | 357573 | Strychnidin-10-one, 2,3- dimethoxy- | 1* | 4 | P018 | B | 100 (45.4) |
| 1,3-Butadiene, 1,1,2,3,4,4- hexachloro- | 87683 | Hexachlorobutadiene | 1* | 2,4 | U128 | X | 1 (0.454) |
| 1-Butanamine, N-butyl-N-nitroso- | 924163 | N-Nitrosodi-n-butylamine | 1* | 4 | U172 | A | 10 (4.54) |
| 1-Butanol | 71363 | n-Butyl alcohol | 1* | 4 | U031 | D | 5000 (2270) |
| 2-Butanone | 78933 | Methyl ethyl ketone (MEK) | 1* | 4 | U159 | D | 5000 (2270) |
| 2-Butanone peroxide | 1338234 | Methyl ethyl ketone peroxide | 1* | 4 | U160 | A | 10 (4.54) |
| 2 Butanone, 3,3-dimethyl-1- (methylthio)-, O[(methylamino) carbonyl] oxime. | 39196184 | Thiofanox | 1* | 4 | P045 | B | 100 (45.4) |
| 2-Butenal | 123739 | Crotonaldehyde | 100 | 1,4 | U053 | B | 100 (45.4) |
| | 4170303 | | | | | | |
| 2-Butene, 1,4-dichloro- | 764410 | 1,4-Dichloro-2-butene | 1* | 4 | U074 | X | 1 (0.454) |
| 2-Butenoic acid, 2-methyl, 7[[2,3- dihydroxy-2-(1-methoxyethyl)-3- methyl-1-oxobutoxy]methyl]- 2,3,5,7a-tetrahydro-1H-pyrrolizin- 1-ylester, [1S-[1alpha(Z), 7(2S*,3R*),7aalpha]]- | 303344 | Lasiocarpine | 1* | 4 | U143 | A | 10 (4.54) |
| Butyl acetate | 123864 | | 5000 | 1 | | D | 5000 (2270) |
| iso-Butyl acetate | 110190 | | 5000 | 1 | | D | 5000 (2270) |
| sec-Butyl acetate | 105464 | | 5000 | 1 | | D | 5000 (2270) |
| tert-Butyl acetate | 540885 | | 5000 | 1 | | D | 5000 (2270) |
| n-Butyl alcohol | 71363 | 1-Butanol | 1* | 4 | U031 | D | 5000 (2270) |
| Butylamine | 109739 | | 1000 | 1 | | C | 1000 (454) |
| iso-Butylamine | 78819 | | 1000 | 1 | | C | 1000 (454) |

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| sec-Butylamine | 513495 | | 1000 | 1 | | C | 1000 (454) |
| | 13952846 | | 1000 | 1 | | C | 1000 (454) |
| tert-Butylamine | 75649 | | 1000 | 1 | | C | 1000 (454) |
| Butyl benzyl phthalate | 85687 | | 1* | 2 | | B | 100 (45.4) |
| n-Butyl phthalate | 84742 | Di-n-butyl phthalate Dibutyl phthalate 1,2-Benzenedicarboxylic acid, dibutyl ester | 100 | 1,2,4 | U069 | A | 10 (4.54) |
| Butyric acid | 107926 | | 5000 | 1 | | D | 5000 (2270) |
| iso-Butyric acid | 79312 | | | | | | |
| Cacodylic acid | 75605 | Arsinic acid, dimethyl- | 1* | 4 | U136 | X | 1 (0.454) |
| Cadmium†† | 7440439 | | 1* | 2 | | A | 10 (4.54) |
| Cadmium acetate | 543908 | | 100 | 1 | | A | 10 (4.54) |
| CADMIUM AND COMPOUNDS | N/A | | 1* | 2 | | | ** |
| Cadmium bromide | 7789426 | | 100 | 1 | | A | 10 (4.54) |
| Cadmium chloride | 10108642 | | 100 | 1 | | A | 10 (4.54) |
| Calcium arsenate | 7778441 | | 1000 | 1 | | X | 1 (0.454) |
| Calcium arsenite | 52740166 | | 1000 | 1 | | X | 1 (0.454) |
| Calcium carbide | 75207 | | 5000 | 1 | | A | 10 (4.54) |
| Calcium chromate | 13765190 | Chromic acid H ₂ CrO ₄ , calcium salt | 1000 | 1,4 | U032 | A | 10 (4.54) |
| Calcium cyanide | 592018 | Calcium cyanide Ca(CN) ₂ | 10 | 1,4 | P021 | A | 10 (4.54) |
| Calcium cyanide Ca(CN) ₂ | 592018 | Calcium cyanide | 10 | 1,4 | P021 | A | 10 (4.54) |
| Calcium dodecylbenzenesulfonate | 26264062 | | 1000 | 1 | | C | 1000 (454) |
| Calcium hypochlorite | 7778543 | | 100 | 1 | | A | 10 (4.54) |
| Camphane, octachloro- | 8001352 | Toxaphene | 1 | 1,2,4 | P123 | X | 1 (0.454) |
| Captan | 133062 | | 10 | 1 | | A | 10 (4.54) |
| Carbamic acid, ethyl ester | 51796 | Ethyl carbamate (urethane) | 1* | 4 | U238 | B | 100 (45.4) |
| Carbamic acid, methylnitroso-, ethyl ester | 615532 | N-Nitroso-N-methylurethane | 1* | 4 | U178 | X | 1 (0.454) |
| Carbamic chloride, dimethyl- | 79447 | Dimethylcarbamoyl chloride | 1* | 4 | U097 | X | 1 (0.454) |
| Carbamodithioic acid, 1,2-ethanediybis, salts & esters | 111546 | Ethylenebisdithiocarbamic acid, salts & esters | 1* | 4 | U114 | D | 5000 (2270) |
| Carbamothioic acid, bis(1-methylethyl)-, S-(2,3-dichloro-2-propenyl) ester | 2303164 | Diallate | 1* | 4 | U062 | B | 100 (45.4) |

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| Carbaryl | 63252 | | 100 | 1 | | B | 100 (45.4) |
| Carbofuran | 1563662 | | 10 | 1 | | A | 10 (4.54) |
| Carbon disulfide | 75150 | | 5000 | 1,4 | P022 | B | 100 (45.4) |
| Carbon oxyfluoride | 353504 | Carbonic difluoride | 1* | 4 | U033 | C | 1000 (454) |
| Carbon tetrachloride | 56235 | Methane, tetrachloro- | 5000 | 1,2,4 | U211 | A | 10 (4.54) |
| Carbonic acid, dithallium(1+) salt | 653739 | Thallium(I) carbonate | 1* | 4 | U215 | B | 100 (45.4) |
| Carbonic dichloride | 75445 | Phosgene | 5000 | 1,4 | P095 | A | 10 (4.54) |
| Carbonic difluoride | 353504 | Carbon oxyfluoride | 1* | 4 | U033 | C | 1000 (454) |
| Carbonochloridic acid, methyl ester | 79221 | Methyl chlorocarbonate Methyl chloroformate | 1* | 4 | U156 | C | 1000 (454) |
| Chloral | 75876 | Acetaldehyde, trichloro- | 1* | 4 | U034 | D | 5000 (2270) |
| Chlorambucil | 305033 | Benzenebutanoic acid, 4-[bis(2-chloroethyl)amino]- | 1* | 4 | U035 | A | 10 (4.54) |
| Chlordane | 57749 | Chlordane, alpha & gamma isomers Chlordane, technical 4,7-Methano-1H-indene, 1,2,4,5,6,7,8,8-octachloro- 2,3,3a,4,7,7a-hexahydro- | 1 | 1,2,4 | U036 | X | 1 (0.454) |
| CHLORDANE (TECHNICAL MIXTURE AND METABOLITES) | N/A | | 1* | 2 | | | ** |
| Chlordane, alpha & gamma isomers | 57749 | Chlordane Chlordane, technical 4,7-Methano-1H-indene, 1,2,4,5,6,7,8,8-octachloro- 2,3,3a,4,7,7a-hexahydro- | 1 | 1,2,4 | U036 | X | 1 (0.454) |
| Chlordane, technical | 57749 | Chlordane Chlordane, alpha & gamma isomers 4,7-Methano-1H-indene, 1,2,4,5,6,7,8,8-octachloro- 2,3,3a,4,7,7a-hexahydro- | 1 | 1,2,4 | U036 | X | 1 (0.454) |
| CHLORINATED BENZENES | N/A | | 1* | 2 | | | ** |
| CHLORINATED ETHANES | N/A | | 1* | 2 | | | ** |
| CHLORINATED NAPHTHALENE | N/A | | 1* | 2 | | | ** |
| CHLORINATED PHENOLS | N/A | | 1* | 2 | | | ** |
| Chlorine | 7782505 | | 10 | 1 | | A | 10 (4.54) |
| Chlornaphazine | 494031 | Naphthalenamine, N,N'-bis(2-chloroethyl)- | 1* | 4 | U026 | B | 100 (45.4) |
| Chloroacetaldehyde | 107200 | Acetaldehyde, chloro- | 1* | 4 | P023 | C | 1000 (454) |

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| CHLOROALKYL ETHERS | N/A | | 1* | 2 | | | ** |
| p-Chloroaniline | 106478 | Benzenamine, 4-chloro- | 1* | 4 | P024 | C | 1000 (454) |
| Chlorobenzene | 108907 | Benzene, chloro- | 100 | 1,2,4 | U037 | B | 100 (45.4) |
| Chlorobenzilate | 510156 | Benzeneacetic acid, 4-chloro-alpha-(4-chloro-phenyl)-alpha-hydroxy-, ethyl ester | 1* | 4 | U038 | A | 10 (4.54) |
| 4-Chloro-m-cresol | 59507 | p-Chloro-m-cresol Phenol, 4-chloro-3-methyl | 1* | 2,4 | U039 | D | 5000 (2270) |
| p-Chloro-m-cresol | 59507 | Phenol, 4-chloro-3-methyl- 4-Chloro-m-cresol | 1* | 2,4 | U039 | D | 5000 (2270) |
| Chlorodibromomethane | 124481 | | 1* | 2 | | B | 100 (45.4) |
| Chloroethane | 75003 | | 1* | 2 | | B | 100 (45.4) |
| 2-Chloroethyl vinyl ether | 110758 | Ethane, 2-chloroethoxy- | 1* | 2,4 | U042 | C | 1000 (454) |
| Chloroform | 67663 | Methane, trichloro- | 5000 | 1,2,4 | U044 | A | 10 (4.54) |
| Chloromethyl methyl ether | 107302 | Methane, chloromethoxy- | 1* | 4 | U046 | A | 10 (4.54) |
| beta-Chloronaphthalene | 91587 | Naphthalene, 2-chloro- 2-Chloronaphthalene | 1* | 2,4 | U047 | D | 5000 (2270) |
| 2-Chloronaphthalene | 91587 | beta-Chloronaphthalene Naphthalene, 2-chloro- | 1* | 2,4 | U047 | D | 5000 (2270) |
| 2-Chlorophenol | 95578 | o-Chlorophenol Phenol, 2-chloro- | 1* | 2,4 | U048 | B | 100 (45.4) |
| o-Chlorophenol | 95578 | Phenol, 2-chloro- 2-Chlorophenol | 1* | 2,4 | U048 | B | 100 (45.4) |
| 4-Chlorophenyl phenyl ether | 7005723 | | 1* | 2 | | D | 5000 (2270) |
| 1-(o-Chlorophenyl)thiourea | 5344821 | Thiourea, (2-chlorophenyl)- | 1* | 4 | P026 | B | 100 (45.4) |
| 3-Chloropropionitrile | 542767 | Propanenitrile, 3-chloro- | 1* | 4 | P027 | C | 1000 (454) |
| Chlorosulfonic acid | 7790946 | | 1000 | 1 | | C | 1000 (454) |
| 4-Chloro-o-toluidine, hydrochloride | 3165933 | Benzenamine, 4-chloro-2-methyl-, hydrochloride | 1* | 4 | U049 | B | 100 (45.4) |
| Chlorpyrifos | 2921882 | | 1 | 1 | | X | 1 (0.454) |
| Chromic acetate | 1066304 | | 1000 | 1 | | C | 1000 (454) |
| Chromic acid | 11115745 | | 1000 | 1 | | A | 10 (4.54) |
| | 7738945 | | 1000 | 1 | | A | 10 (4.54) |
| Chromic acid H ₂ CrO ₄ , calcium salt | 13765190 | Calcium chromate | 1000 | 1,4 | U032 | A | 10 (4.54) |
| Chromic sulfate | 10101538 | | 1000 | 1 | | C | 1000 (454) |
| Chromium†† | 7440473 | | 1* | 2 | | D | 5000 (2270) |

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| | | | RQ | Code† | RCRA Waste # | Cate-gory | Pounds (Kg) |
| CHROMIUM AND COMPOUNDS | N/A | | 1* | 2 | | | ** |
| Chromous chloride | 10049055 | | 1000 | 1 | | C | 1000 (454) |
| Chrysene | 218019 | 1,2-Benzphenanthrene | 1* | 2,4 | U050 | B | 100 (45.4) |
| Cobaltous bromide | 7789437 | | 1000 | 1 | | C | 1000 (454) |
| Cobaltous formate | 544183 | | 1000 | 1 | | C | 1000 (454) |
| Cobaltous sulfamate | 14017415 | | 1000 | 1 | | C | 1000 (454) |
| Coke Oven Emissions | N/A | | 1* | 3 | | X | 1 (0.454) |
| Copper cyanide CuCN | 544923 | Copper cyanide | 1* | 4 | P029 | A | 10 (4.54) |
| Copper†† | 7440508 | | 1* | 2 | | D | 5000 (2270) |
| COPPER AND COMPOUNDS | N/A | | 1* | 2 | | | ** |
| Copper cyanide | 544923 | Copper cyanide CuCN | 1* | 4 | P029 | A | 10 (4.54) |
| Coumaphos | 56724 | | 10 | 1 | | A | 10 (4.54) |
| Creosote | 8001589 | | 1* | 4 | U051 | X | 1 (0.454) |
| Cresol(s) | 1319773 | Cresylic acid Phenol, methyl- | 1000 | 1,4 | U052 | C | 1000 (454) |
| m-Cresol | 108394 | m-Cresylic acid | 1000 | 1,4 | U052 | C | 1000 (454) |
| o-Cresol | 95487 | o-Cresylic acid | 1000 | 1,4 | U052 | C | 1000 (454) |
| p-Cresol | 106445 | p-Cresylic acid | 1000 | 1,4 | U052 | C | 1000 (454) |
| Cresylic acid | 1319773 | Cresol(s) Phenol, methyl- | 1000 | 1,4 | U052 | C | 1000 (454) |
| m-Cresol | 108394 | m-Cresylic acid | 1000 | 1,4 | U052 | C | 1000 (454) |
| o-Cresol | 95487 | o-Cresylic acid | 1000 | 1,4 | U052 | C | 1000 (454) |
| p-Cresol | 106445 | p-Cresylic acid | 1000 | 1,4 | U052 | C | 1000 (454) |
| Crotonaldehyde | 123739 | 2-Butenal | 100 | 1,4 | U053 | B | 100 (45.4) |
| | 4170303 | | | | | | |
| Cumene | 98828 | Benzene, 1-methylethyl- | 1* | 4 | U055 | D | 5000 (2270) |
| Cupric acetate | 142712 | | 100 | 1 | | B | 100 (45.4) |
| Cupric acetoarsenite | 12002038 | | 100 | 1 | | X | 1 (0.454) |
| Cupric chloride | 7447394 | | 10 | 1 | | A | 10 (4.54) |
| Cupric nitrate | 3251238 | | 100 | 1 | | B | 100 (45.4) |
| Cupric oxalate | 5893663 | | 100 | 1 | | B | 100 (45.4) |
| Cupric sulfate | 7758987 | | 10 | 1 | | A | 10 (4.54) |
| Cupric sulfate, ammoniated | 10380297 | | 100 | 1 | | B | 100 (45.4) |

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| Cupric tartrate | 815827 | | 100 | 1 | | B | 100 (45.4) |
| CYANIDES | N/A | | 1* | 2 | | | ** |
| Cyanides (soluble salts and complexes) not otherwise specified | 57125 | | 1* | 4 | PO30 | A | 10 (4.54) |
| Cyanogen | 460195 | Ethanedinitrile | 1* | 4 | PO31 | B | 100 (45.4) |
| Cyanogen bromide | 506683 | Cyanogen bromide (CN)Br | 1* | 4 | U246 | C | 1000 (454) |
| Cyanogen bromide (CN)Br | 506683 | Cyanogen bromide | 1* | 4 | U246 | C | 1000 (454) |
| Cyanogen chloride | 506774 | Cyanogen chloride (CN)Cl | 10 | 1,4 | PO33 | A | 10 (4.54) |
| Cyanogen chloride (CN)Cl | 506774 | Cyanogen chloride | 10 | 1,4 | PO33 | A | 10 (4.54) |
| 2,5-Cyclohexadiene-1,4-dione | 106514 | p-Benzoquinone | 1* | 4 | U197 | A | 10 (4.54) |
| Cyclohexane | 110827 | Benzene, hexahydro- | 1000 | 1,4 | U056 | C | 1000 (454) |
| Cyclohexane, 1,2,3,4,5,6-hexachloro-, (1alpha, 2alpha, 3beta, 4alpha, 5alpha, 6beta)- | 58899 | gamma-BHC | 1 | 1,2,4 | U129 | X | 1 (0.454) |
| Cyclohexanone | 108941 | | 1* | 4 | U057 | D | 5000 (2270) |
| 2-Cyclohexyl-4,6-dinitrophenol | 131895 | Phenol, 2-cyclohexyl-4,6-dinitro- | 1* | 4 | PO34 | B | 100 (45.4) |
| 1,3-Cyclopentadiene, 1,2,3,4,5,5-hexachloro- | 77474 | Hexachlorocyclopentadiene | 1 | 1,2,4 | U130 | A | 10 (4.54) |
| Cyclophosphamide | 50180 | 2H-1,3,2-Oxazaphosphorin-2-amine, N,N-bis(2-chloroethyl) tetrahydro-, 2-oxide | 1* | 4 | U058 | A | 10 (4.54) |
| 2,4-D Acid | 94757 | Acetic acid (2,4-dichlorophenoxy)-2,4-D, salts and esters | 100 | 1,4 | U240 | B | 100 (45.4) |
| 2,4-D Ester | 94111 | | 100 | 1 | | B | 100 (45.4) |
| | 94791 | | 100 | 1 | | B | 100 (45.4) |
| | 94804 | | 100 | 1 | | B | 100 (45.4) |
| | 1320189 | | 100 | 1 | | B | 100 (45.4) |
| | 1928387 | | 100 | 1 | | B | 100 (45.4) |
| | 1928616 | | 100 | 1 | | B | 100 (45.4) |
| | 1929733 | | 100 | 1 | | B | 100 (45.4) |
| | 2971382 | | 100 | 1 | | B | 100 (45.4) |
| | 25168267 | | 100 | 1 | | B | 100 (45.4) |
| | 53467111 | | 100 | 1 | | B | 100 (45.4) |
| 2,4-D, salts and esters | 94757 | Acetic acid (2,4-dichlorophenoxy)-2,4-D Acid | 100 | 1,4 | U240 | B | 100 (45.4) |

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| Daunomycin | 20830813 | 5,12-Naphthacenedione, 8-acetyl-10-[3-amino-2,3,6-trideoxy-alpha-L-lyxo-hexo-pyranosyl)oxy]-7,8,9,10-tetrahydro-6,8,11-trihydroxy-1-methoxy-, (8S-cis)- | 1* | 4 | U059 | A | 10 (4.54) |
| DDD | 72548 | Benzene, 1,1'-(2,2-dichloroethylidene)bis[4-chloro-TDE 4,4' DDD | 1 | 1,2,4 | U060 | X | 1 (0.454) |
| 4,4' DDD | 72548 | Benzene, 1,1'-(2,2-dichloroethylidene)bis[4-chloro-DDD TDE | 1 | 1,2,4 | U060 | X | 1 (0.454) |
| DDE | 72559 | 4,4' DDE | 1* | 2 | | X | 1 (0.454) |
| 4,4' DDE | 72559 | DDE | 1* | 2 | | X | 1 (0.454) |
| DDT | 50293 | Benzene, 1,1'-(2,2,2-trichloroethylidene)bis[4-chloro-4,4' DDT | 1 | 1,2,4 | U061 | X | 1 (0.454) |
| 4,4' DDT | 50293 | Benzene, 1,1'-(2,2,2-trichloroethylidene)bis[4-chloro-DDT | 1 | 1,2,4 | U061 | X | 1 (0.454) |
| DDT AND METABOLITES | N/A | | 1* | 2 | | | ** |
| Diallate | 2303164 | Carbamothioic acid, bis(1-methylethyl)-, S-(2,3-dichloro-2-propenyl) ester | 1* | 4 | U062 | B | 100 (45.4) |
| Diazinon | 333415 | | 1 | 1 | | X | 1 (0.454) |
| Dibenz[a,h]anthracene | 53703 | Dibenzo[a,h]anthracene 1,2:5,6-Dibenzanthracene | 1* | 2,4 | U063 | X | 1 (0.454) |
| 1,2:5,6-Dibenzanthracene | 53703 | Dibenzo[a,h]anthracene Dibenzo[a,h]anthracene | 1* | 2,4 | U063 | X | 1 (0.454) |
| Dibenzo[a,h]anthracene | 53703 | Dibenzo[a,h]anthracene 1,2:5,6-Dibenzanthracene | 1* | 2,4 | U063 | X | 1 (0.454) |
| Dibenz[a,i]pyrene | 189559 | Benzo[rs]t]pentaphene | 1* | 4 | U064 | A | 10 (4.54) |
| 1,2-Dibromo-3-chloropropane | 96128 | Propane, 1,2-dibromo-3-chloro- | 1* | 4 | U066 | X | 1 (0.454) |
| Dibutyl phthalate | 84742 | Dibutyl phthalate n-Butyl phthalate 1,2-Benzenedicarboxylic acid, dibutyl ester | 100 | 1,2,4 | U069 | A | 10 (4.54) |
| Di-n-butyl phthalate | 84742 | Dibutyl phthalate n-Butyl phthalate 1,2-Benzenedicarboxylic acid, dibutyl ester | 100 | 1,2,4 | U069 | A | 10 (4.54) |
| Dicamba | 1918009 | | 1000 | 1 | | C | 1000 (454) |

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| | | | RQ | Code† | RCRA Waste # | Category | Pounds (Kg) |
| Dichlobenil | 1194656 | | 1000 | 1 | | B | 100 (45.4) |
| Dichlone | 117806 | | 1 | 1 | | X | 1 (0.454) |
| Dichlorobenzene | 25321226 | | 100 | 1 | | B | 100 (45.4) |
| 1,2-Dichlorobenzene | 95501 | Benzene, 1,2-dichloro- o-Dichlorobenzene | 100 | 1,2,4 | U070 | B | 100 (45.4) |
| 1,3-Dichlorobenzene | 541731 | Benzene, 1,3-dichloro m-Dichlorobenzene | 1* | 2,4 | U071 | B | 100 (45.4) |
| 1,4-Dichlorobenzene | 106467 | Benzene, 1,4-dichloro p-Dichlorobenzene | 100 | 1,2,4 | U072 | B | 100 (45.4) |
| m-Dichlorobenzene | 541731 | Benzene, 1,3-dichloro 1,3-Dichlorobenzene | 1* | 2,4 | U071 | B | 100 (45.4) |
| o-Dichlorobenzene | 95501 | Benzene, 1,2-dichloro 1,2-Dichlorobenzene | 100 | 1,2,4 | U070 | B | 100 (45.4) |
| p-Dichlorobenzene | 106467 | Benzene, 1,4-dichloro 1,4-Dichlorobenzene | 100 | 1,2,4 | U072 | B | 100 (45.4) |
| DICHLOROBENZIDINE | N/A | | 1* | 2 | | | ** |
| 3,3'-Dichlorobenzidine | 91941 | [1,1'-Biphenyl]-4,4'-diamine,3,3'dichloro- | 1* | 2,4 | U073 | X | 1 (0.454) |
| Dichlorobromomethane | 75274 | | 1* | 2 | | D | 5000 (2270) |
| 1,4-Dichloro-2-butene | 764410 | 2-Butene, 1,4-dichloro- | 1* | 4 | U074 | X | 1 (0.454) |
| Dichlorodifluoromethane | 75718 | Methane, dichlorodifluoro- | 1* | 4 | U075 | D | 5000 (2270) |
| 1,1-Dichloroethane | 75343 | Ethane, 1,1-dichloro-Ethylidene dichloride | 1* | 2,4 | U076 | C | 1000 (454) |
| 1,2-Dichloroethane | 107062 | Ethane, 1,2-dichloro-Ethylene dichloride | 5000 | 1,2,4 | U077 | B | 100 (45.4) |
| 1,1-Dichloroethylene | 75354 | Ethene, 1,1-dichloro-Vinylidene chloride | 5000 | 1,2,4 | U078 | B | 100 (45.4) |
| 1,2-Dichloroethylene | 156605 | Ethene 1,2-dichloro- (E) | 1* | 2,4 | U079 | C | 1000 (454) |
| Dichloroethyl ether | 111444 | Bis (2-chloroethyl) ether Ethane, 1,1'-oxybis[2-chloro- | 1* | 2,4 | U025 | A | 10 (4.54) |
| Dichloroisopropyl ether | 108601 | Propane, 2,2'-oxybis[2-chloro- | 1* | 2,4 | U027 | C | 1000 (454) |
| Dichloromethoxy ethane | 111911 | Bis(2-chloroethoxy) methane Ethane, 1,1'-[methylenebis(oxy)] bis(2-chloro- | 1* | 2,4 | U024 | C | 1000 (454) |
| Dichloromethyl ether | 542881 | Methane, oxybis(chloro- | 1* | 4 | P016 | A | 10 (4.54) |
| 2,4-Dichlorophenol | 120832 | Phenol, 2,4-dichloro- | 1* | 2,4 | U081 | B | 100 (45.4) |
| 2,6-Dichlorophenol | 87650 | Phenol, 2,6-dichloro- | 1* | 4 | U082 | B | 100 (45.4) |
| Dichlorophenylarsine | 696286 | Arsonous dichloride, phenyl- | 1* | 4 | P036 | X | 1 (0.454) |

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| | | | RQ | Code † | RCRA Waste # | Category | Pounds (Kg) |
| Dichloropropane | 26638197 | | 5000 | 1 | | C | 1000 (454) |
| 1,1-Dichloropropane | 78999 | | 5000 | 1 | | C | 1000 (454) |
| 1,3-Dichloropropane | 142289 | | 5000 | 1 | | C | 1000 (454) |
| 1,2-Dichloropropane | 78875 | Propane, 1,2-dichloro-Propylene dichloride | 5000 | 1,2,4 | U083 | C | 1000 (454) |
| Dichloropropane—Dichloropropene (mixture) | 8003198 | | 5000 | 1 | | B | 100 (45.4) |
| Dichloropropene | 26952238 | | 5000 | 1 | | B | 100 (45.4) |
| 2,3-Dichloropropene | 78886 | | 5000 | 1 | | B | 100 (45.4) |
| 1,3-Dichloropropene | 542756 | 1-Propene, 1,3-dichloro- | 5000 | 1,2,4 | U084 | B | 100 (45.4) |
| 2,2-Dichloropropionic acid | 75990 | | 5000 | 1 | | D | 5000 (2270) |
| Dichlorvos | 627737 | | 10 | 1 | | A | 10 (4.54) |
| Dicofol | 115322 | | 5000 | 1 | | A | 5000 (2270) |
| Dieldrin | 60571 | 2,7:3,6-Dimethanonaphth[2,3-b]oxirene,3,4,5,6,9,9-hexachloro-1a,2,2a,3,6,6a,7,7a-octahydro-, (1aalpha,2beta,2aalpha,3beta,6beta,6aalpha,7beta,7aalpha)- | 1 | 1,2,4 | P037 | X | 1 (0.454) |
| 1,2:3,4-Diepoxybutane | 1464535 | 2,2'-Bioxirane | 1* | 4 | U085 | A | 10 (4.54) |
| Diethylamine | 109897 | | 1000 | 1 | | B | 100 (45.4) |
| Diethylarsine | 692422 | Arsine, diethyl- | 1* | 4 | P038 | X | 1 (0.454) |
| 1,4-Diethylenedioxiide | 123911 | 1,4-Dioxane | 1* | 4 | U108 | B | 100 (45.4) |
| Diethylhexyl phthalate | 117817 | Bis (2-ethylhexyl)phthalate 1,2,-Benzenedicarboxylic acid, [bis(2-ethylhexyl)] ester | 1* | 2,4 | U028 | B | 100 (45.4) |
| N,N'-Diethylhydrazine | 1615801 | Hydrazine, 1,2-diethyl- | 1* | 4 | U086 | A | 10 (4.54) |
| O,O-Diethyl S-methyl dithiophosphate | 3288582 | Phosphorodithioic acid, O,O-diethyl S-methyl ester | 1* | 4 | U087 | D | 5000 (2270) |
| Diethyl-p-nitrophenyl phosphate | 311455 | Phosphoric acid, diethyl 4-nitrophenyl ester | 1* | 4 | P041 | B | 100 (45.4) |
| Diethyl phthalate | 84662 | 1,2-Benzenedicarboxylic acid, diethyl ester | 1* | 2,4 | U088 | C | 1000 (454) |
| O,O-Diethyl O-pyrazinyl phosphorothioate | 297972 | Phosphorothioic acid, O,O-diethyl O-pyrazinyl ester | 1* | 4 | P040 | B | 100 (45.4) |
| Diethylstilbestrol | 56531 | Phenol, 4,4'-(1,2-diethyl-1,2-ethenediyl)bis-, (E) | 1* | 4 | U089 | X | 1 (0.454) |
| Dihydrosafrole | 94586 | 1,3-Benzodioxole, 5-propyl- | 1* | 4 | U090 | A | 10 (4.54) |

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| | | | RQ | Code† | RCRA Waste # | Category | Pounds (Kg) |
| Diisopropylfluorophosphate | 55914 | Phosphorofluoridic acid, bis(1-methylethyl) ester | 1* | 4 | P043 | B | 100 (45.4) |
| 1,4,5,8-Dimethanonaphthalene, 1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-, (1alpha,4alpha,4abeta,5alpha,8alpha, | 309002 | Aldrin | 1 | 1,2,4 | P004 | X | 1 (0.454) |
| 8abeta)-1,4,5,8-Dimethanonaphthalene, 1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro,(1alpha,4alpha,4abeta,5abeta,8beta, | 465736 | Isodrin | 1* | 4 | P060 | X | 1 (0.454) |
| 8abeta)-2,7:3,6-Dimethanonaphth[2,3-b]oxirene, 3,4,5,6,9,9-hexachloro-1a,2,2a,3,6,6a,7,7a-octahydro-, (1alpha,2beta,2alpha,3beta,6beta, | 60571 | Dieldrin | 1 | 1,2,4 | P037 | X | 1 (0.454) |
| 6alpha,7beta,7alpha)-2,7:3,6-Dimethanonaphth[2,3-b]oxirene, 3,4,5,6,9,9-hexachloro-1a,2,2a,3,6,6a,7,7a-octa-hydro-,(1alpha,2beta,2abeta,3alpha,6alpha, | 72208 | Endrin Endrin & metabolites | 1 | 1,2,4 | P051 | X | 1 (0.454) |
| 6beta,7beta,7alpha)-Dimethoate | 60515 | Phosphorodithioic acid, O,O-dimethyl S-[2(methylamino)-2-oxoethyl] ester | 1* | 4 | P044 | A | 10 (4.54) |
| 3,3'-Dimethoxybenzidine | 119904 | [1,1'-Biphenyl]-4,4'diamine,3,3'dimethoxy- | 1* | 4 | U091 | B | 100 (45.4) |
| Dimethylamine | 124403 | methanamine, N-methyl | 1000 | 1,4 | U092 | C | 1000 (454) |
| p-Dimethylaminoazobenzene | 60117 | Benzenamine, N,N-dimethyl-4-(phenylazo-) | 1* | 4 | U093 | A | 10 (4.54) |
| 7,12-Dimethylbenz[a]anthracene | 57976 | Benz[a]anthracene, 7,12-dimethyl- | 1* | 4 | U094 | X | 1 (0.454) |
| 3,3'-Dimethylbenzidine | 119937 | [1,1'Biphynyl]-4,4'diamine,3,3'-dimethyl- | 1* | 4 | U095 | A | 10 (4.54) |
| alpha,alpha-Dimethylbenzylhydroperoxide | 80159 | Hydroperoxide, 1-methyl-1-phenylethyl- | 1* | 4 | U096 | A | 10 (4.54) |
| Dimethylcarbamoyl chloride | 79447 | Carbamic chloride, dimethyl- | 1* | 4 | U097 | X | 1 (0.454) |
| 1,1-Dimethylhydrazine | 57147 | Hydrazine, 1,1-dimethyl- | 1* | 4 | U098 | A | 10 (4.54) |
| 1,2-Dimethylhydrazine | 540738 | Hydrazine, 1,2-dimethyl- | 1* | 4 | U099 | X | 1 (0.454) |
| alpha,alpha-Dimethylphenethylamine | 122098 | Benzeneethanamine, alpha,alpha-dimethyl- | 1* | 4 | P046 | D | 5000 (2270) |
| 2,4-Dimethylphenol | 105679 | Phenol, 2,4-dimethyl- | 1* | 2,4 | U101 | B | 100 (45.4) |

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| Dimethyl phthalate | 131113 | 1,2-Benzenedicarboxylic acid, dimethyl ester | 1* | 2,4 | U102 | D | 5000 (2270) |
| Dimethyl sulfate | 77781 | Sulfuric acid, dimethyl ester | 1* | 4 | U103 | B | 100 (45.4) |
| Dinitrobenzene (mixed) | 25154545 | | 1000 | 1 | | B | 100 (45.4) |
| m-Dinitrobenzene | 99650 | | 1000 | 1 | | B | 100 (45.4) |
| o-Dinitrobenzene | 528290 | | 1000 | 1 | | B | 100 (45.4) |
| p-Dinitrobenzene | 100254 | | 1000 | 1 | | B | 100 (45.4) |
| 4,6-Dinitro-o-cresol and salts | 534521 | Phenol, 2-methyl-4,6-dinitro- | 1* | 2,4 | P047 | A | 10 (4.54) |
| Dinitrophenol | 25550587 | | 1000 | 1 | | A | 10 (4.54) |
| 2,5-Dinitrophenol | 329715 | | 1000 | 1 | | A | 10 (4.54) |
| 2,6-Dinitrophenol | 573568 | | 1000 | 1 | | A | 10 (4.54) |
| 2,4-Dinitrophenol | 51285 | Phenol, 2,4-dinitro- | 1000 | 1,2,4 | P048 | A | 10 (4.54) |
| Dinitrotoluene | 25321146 | | 1000 | 1,2 | | A | 10 (4.54) |
| 3,4-Dinitrotoluene | 610399 | | | | | | |
| 2,4-Dinitrotoluene | 121142 | Benzene, 1-methyl-2,4-dinitro- | 1000 | 1,2,4 | U105 | A | 10 (4.54) |
| 2,6-Dinitrotoluene | 606202 | Benzene, 2-methyl-1,3-dinitro- | 1000 | 1,2,4 | U106 | B | 100 (45.4) |
| Dinoseb | 88857 | Phenol, 2-(1-methylpropyl)-4,6-dinitro | 1* | 4 | P020 | C | 1000 (454) |
| Di-n-octyl phthalate | 117840 | 1,2-Benzenedicarboxylic acid, dioctyl ester | 1* | 2,4 | U107 | D | 5000 (2270) |
| 1,4-Dioxane | 123911 | 1,4-Diethylenedioxiide | 1* | 4 | U108 | B | 100 (45.4) |
| DIPHENYLHYDRAZINE | N/A | | 1* | 2 | | | ** |
| 1,2-Diphenylhydrazine | 122667 | Hydrazine, 1,2-diphenyl | 1* | 2,4 | U109 | A | 10 (4.54) |
| Diphosphoramidate, octamethyl- | 152169 | Octamethylpyrophosphoramidate | 1* | 4 | P085 | B | 100 (45.4) |
| Diphosphoric acid, tetraethyl ester | 107493 | Tetraethyl pyrophosphate | 100 | 1,4 | P111 | A | 10 (4.54) |
| Dipropylamine | 142847 | 1-Propanamine, N-propyl- | 1* | 4 | U110 | D | 5000 (2270) |
| Di-n-propylnitrosamine | 621647 | 1-Propanamine, N-nitroso-N-propyl- | 1* | 2,4 | U111 | A | 10 (4.54) |
| Diquat | 85007 | | 1000 | 1 | | C | 1000 (454) |
| | 2764729 | | 1000 | 1 | | C | 1000 (454) |
| Disulfoton | 298044 | Phosphorodithioic acid, o,o-diethyl S-[2-(ethylthio)ethyl]ester | 1 | 1,4 | P039 | X | 1 (0.454) |
| Dithiobiuret | 541537 | Thiomidodicarbonic diamide [(H2N)C(S)]2NH | 1* | 4 | P049 | B | 100 (45.4) |
| Diuron | 330541 | | 100 | 1 | | B | 100 (45.4) |

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| Dodacylbenzenesulfonic acid | 27176870 | | 1000 | 1 | | C | 1000 (454) |
| Endosulfan | 115297 | 6,9-Methano-2,4,3-benzodioxathiepin, 6,7,8,9,10,10-hexachloro-1,5,6a,6,9,9a-hexahydro-, 3-oxide | 1 | 1,2,4 | P050 | X | 1 (0.454) |
| alpha - Endosulfan | 959988 | | 1* | 2 | | X | 1 (0.454) |
| beta - Endosulfan | 33213659 | | 1* | 2 | | X | 1 (0.454) |
| ENDOSALFAN AND METABOLITES | N/A | | 1* | 2 | | | ** |
| Endosulfan sulfate | 1031078 | | 1* | 2 | | X | 1 (0.454) |
| Endothall | 145733 | 7-Oxabicyclo[2.2.1]heptane-2,3-dicarboxylic acid | 1* | 4 | P088 | C | 1000 (454) |
| Endrin | 72208 | Endrin, & metabolites 2,7:3,6-Dimethanonaphth[2,3-b]oxirene,3,4,5,6,9,9-hexachloro-1a,2,2a,3,6,6a,7,7a-octa-hydro-, (1 aalpha, 2beta,2abeta,3alpha, 6alpha,6abeta,7beta, 7aalpha)- | 1 | 1,2,4 | P051 | X | 1 (0.454) |
| Endrin aldehyde | 7421934 | | 1* | 2 | | X | 1 (0.454) |
| ENDRIN AND METABOLITES | N/A | | 1* | 2 | | | ** |
| Endrin, & metablites | 72208 | Endrin 2,7:3,6-Dimethanonaphth[2,3-b] oxirene, 3,4,5,6,9,9-hexachloro-1a,2,2a,3,6,6a,7,7a-octa-hydro-, (1 aalpha,2beta, 2abeta,3alpha, 6alpha, 6abeta,7beta, 7aalpha)- | 1 | 1,2,4 | P051 | X | 1 (0.454) |
| Epichlorohydrin | 106898 | Oxirane, (chloromethyl)- | 1000 | 1,4 | U041 | B | 100 (45.4) |
| Epinephrine | 51434 | 1,2-Benzenediol,4-[1-hydroxy-2-(methylamino)ethyl]- | 1* | 4 | P042 | C | 1000 (454) |
| Ethanal | 75070 | Acetaldehyde | 1000 | 1,4 | U001 | C | 1000 (454) |
| Ethanamine, N-ethyl-N-nitroso- | 55185 | N-Nitrosodiethylamine | 1* | 4 | U174 | X | 1 (0.454) |
| 1,2-Ethanediamine, N,N-dimethyl-N'-2-pyridinyl-N'-(2-thienylmethyl)- | 91805 | Methapyrilene | 1* | 4 | U155 | D | 5000 (2270) |
| Ethane, 1,2-dibromo- | 106934 | Ethylene dibromide | 1000 | 1,4 | U067 | X | 1 (0.454) |
| Ethane, 1,1-dichloro- | 75343 | Ethylidene dichloride 1,1-Dichloroethane | 1* | 2,4 | U076 | C | 1000 (454) |
| Ethane, 1,2-dichloro- | 107062 | Ethylene dichloride 1,2-Dichlorethane | 5000 | 1,2,4 | U077 | B | 100 (45.4) |
| Ethanedinitrile | 460195 | Cyanogen | 1* | 4 | P031 | B | 100 (45.4) |

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| Ethane, hexachloro- | 67721 | Hexachloroethane | 1* | 2,4 | U131 | B | 100 (45.4) |
| Ethane, 1,1'-[methylenebis(oxy)]bis(2-chloro- | 111911 | Bis(2-chloroethoxy) methane Dichloromethoxy ethane | 1* | 2,4 | U024 | C | 1000 (454) |
| Ethane, 1,1'-oxybis- | 60297 | Ethyl ether | 1* | 4 | U117 | B | 100 (45.4) |
| Ethane, 1,1'-oxybis[2-chloro- | 111444 | Bis (2-chloroethyl) ether Dichloroethyl ether | 1* | 2,4 | U025 | A | 10 (4.54) |
| Ethane, pentachloro- | 76017 | Pentachloroethane | 1* | 4 | U184 | A | 10 (4.54) |
| Ethane, 1,1,1,2-tetrachloro | 630206 | 1,1,1,2-Tetrachloroethane | 1* | 4 | U208 | B | 100 (45.4) |
| Ethane, 1,1,2,2-tetrachloro | 79345 | 1,1,2,2-Tetrachloroethane | 1* | 2,4 | U209 | B | 100 (45.4) |
| Ethanethioamide | 62555 | Thioacetamide | 1* | 4 | U218 | A | 10 (4.54) |
| Ethane, 1,1,1-trichloro | 71556 | Methyl chloroform 1,1,1-Trichloroethane | 1* | 2,4 | U226 | C | 1000 (454) |
| Ethane, 1,1,2-trichloro- | 79005 | 1,1,2-Trichloroethane | 1* | 2,4 | U227 | B | 100 (45.4) |
| Ethanimidothioic acid, N-[(methyl-amino)carbonyl]oxy]-, methyl ester | 16752775 | Methomyl | 1* | 4 | P066 | B | 100 (45.4) |
| Ethanol, 2-ethoxy- | 110805 | Ethylene glycol monoethyl ether | 1* | 4 | U359 | C | 1000 (454) |
| Ethanol, 2,2'-(nitrosoimino)bis- | 1116547 | N-Nitrosodiethanolamine | 1* | 4 | U173 | X | 1 (0.454) |
| Ethanone, 1-phenyl- | 98862 | Acetophenone | 1* | 4 | U004 | D | 5000 (2270) |
| Ethene, chloro- | 75014 | Vinyl chloride | 1* | 2,3,4 | U043 | X | 1 (0.454) |
| Ethene, 2-Chloroethoxy- | 110758 | 2-Chloroethyl vinyl ether | 1* | 2,4 | U042 | C | 1000 (454) |
| Ethene, 1,1-dichloro- | 75354 | Vinylidene chloride 1,1-Dichloroethylene | 5000 | 1,2,4 | U078 | B | 100 (45.4) |
| Ethene, 1,2-dichloro- | 156605 | 1,2-Dichloroethylene | 1* | 2,4 | U079 | C | 1000 (45.4) |
| Ethene, tetrachloro- | 127184 | Perchloroethylene Tetrachlorethene Tetrachloroethylene | 1* | 2,4 | U210 | B | 100 (45.4) |
| Ethene, trichloro- | 79016 | Trichloroethene Trichloroethylene | 1000 | 1,2,4 | U228 | B | 100 (45.4) |
| Ethion | 563122 | | 10 | 1 | | A | 10 (4.54) |
| Ethyl acetate | 141786 | Acetic acid, ethyl ester | 1* | 4 | U112 | D | 5000 (2270) |
| Ethyl acrylate | 140885 | 2-Propenoic acid, ethyl ester | 1* | 4 | U113 | C | 1000 (454) |
| Ethylbenzene | 100414 | | 1000 | 1,2 | | C | 1000 (454) |
| Ethyl carbamate (urethane) | 51796 | Carbamic acid, ethyl ester | 1* | 4 | U238 | B | 100 (45.4) |
| Ethyl cyanide | 107120 | Propanenitril | 1* | 4 | P101 | A | 10 (4.54) |

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| Ethylenebisdithiocarbamic acid, salts & esters | 111546 | Carbamodithioic acid, 1,2-ethanediybis, salts & esters | 1* | 4 | U114 | D | 5000 (2270) |
| Ethylenediamine | 107153 | | 1000 | 1 | | D | 5000 (2270) |
| Ethylenediamine-tetraacetic acid (EDTA) | 60004 | | 5000 | 1 | | D | 5000 (2270) |
| Ethylene dibromide | 106934 | Ethane, 1,2-dibromo- | 1000 | 1,4 | U067 | X | 1 (0.454) |
| Ethylene dichloride | 107062 | Ethane, 1,2-dichloro-1,2-Dichloroethane | 5000 | 1,2,4 | U077 | B | 100 (45.4) |
| Ethylene glycol monoethyl ether | 110805 | Ethanol, 2-ethoxy- | 1* | 4 | U359 | C | 1000 (454) |
| Ethylene oxide | 75218 | Oxirane | 1* | 4 | U115 | A | 10 (4.54) |
| Ethylanthiurea | 96457 | 2-Imidazolidinethione | 1* | 4 | U116 | A | 10 (4.54) |
| Ethylenimine | 151564 | Aziridine | 1* | 4 | P054 | X | 1 (0.454) |
| Ethyl ether | 60297 | Ethane, 1,1'-oxybis | 1* | 4 | U117 | B | 100 (45.4) |
| Ethylidene dichloride | 75343 | Ethane, 1,1'-dichloro-1,1-Dichloroethane | 1* | 2,4 | U076 | C | 1000 (454) |
| Ethyl methacrylate | 97632 | 2-Propenoic acid, 2-methyl-, ethyl ester | 1* | 4 | U118 | C | 1000 (454) |
| Ethyl methanesulfonate | 62500 | Methanesulfonic acid, ethyl ester | 1* | 4 | U119 | X | 1 (0.454) |
| Famphur | 52857 | Phosphorothioic acid, O,[4-[(dimethylamino) sulfonyl] phenyl] O,O-dimethyl ester | 1* | 4 | P097 | C | 1000 (454) |
| Ferric ammonium citrate | 1185575 | | 1000 | 1 | | C | 1000 (454) |
| Ferric ammonium oxalate | 2944674 | | 1000 | 1 | | C | 1000 (454) |
| | 55488874 | | 1000 | 1 | | C | 1000 (454) |
| Ferric chloride | 7705080 | | 1000 | 1 | | C | 1000 (454) |
| Ferric flouride | 7783508 | | 100 | 1 | | B | 100 (45.4) |
| Ferric nitrate | 10421484 | | 1000 | 1 | | C | 1000 (454) |
| Ferric sulfate | 10028225 | | 1000 | 1 | | C | 1000 (454) |
| Ferrous ammonium sulfate | 10045893 | | 1000 | 1 | | C | 1000 (454) |
| Ferrous chloride | 7758943 | | 100 | 1 | | B | 100 (45.4) |
| Ferrous sulfate | 7720787 | | 1000 | 1 | | C | 1000 (454) |
| | 7782630 | | 1000 | 1 | | C | 1000 (454) |
| Flouranthene | 206440 | Benzo[j,k]flourene | 1* | 2,4 | U120 | B | 100 (45.4) |
| Flourene | 86737 | | 1* | 2 | | D | 5000 (2270) |
| Flourine | 7782414 | | 1* | 4 | P056 | A | 10 (4.54) |

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| Flouroacetamide | 640197 | Acetamide, 2-fluoro- | 1* | 4 | P057 | B | 100 (45.4) |
| Flouracetic acid, sodium salt | 62748 | Acetic acid, fluoro-, sodium salt | 1* | 4 | P058 | A | 10 (4.54) |
| Formaldehyde | 50000 | | 1000 | 1,4 | U122 | B | 100 (45.4) |
| Formic acid | 64186 | | 5000 | 1,4 | U123 | D | 5000 (2270) |
| Fulminic acid, mercury(2+)salt | 628864 | Mercury fulminate | 1* | 4 | P065 | A | 10 (4.54) |
| Fumaric acid | 110178 | | 5000 | 1 | | D | 5000 (2270) |
| Furan | 110009 | Furfuran | 1* | 4 | U124 | B | 100 (45.4) |
| Furan, tetrahydro- | 109999 | Tetrahydrofuran | 1* | 4 | U213 | C | 1000 (454) |
| 2-Furancarboxaldehyde | 98011 | Furfural | 1000 | 1,4 | U125 | D | 5000 (2270) |
| 2,5-Furandione | 108316 | Maleic anhydride | 5000 | 1,4 | U147 | D | 5000 (2270) |
| Furfural | 98011 | 2-Furancarboxaldehyde | 1000 | 1,4 | U125 | D | 5000 (2270) |
| Furfuran | 110009 | Furan | 1* | 4 | U124 | B | 100 (45.4) |
| Glucopyranose, 2-deoxy-2-(3-methyl-3-nitrosoureido)- | 18883664 | D-Glucose, 2-deoxy-2-[[[(methylnitrosoamino)-carbonyl]amino] Streptozotocin | 1* | 4 | U206 | X | 1 (0.454) |
| D-Glucose, 2-deoxy-2-[[[(methylnitrosoamino)-carbonyl]amino]- | 18883664 | Glucopyranose, 2-deoxy-2-(3-methyl-3-nitrosoureido)- | 1* | 4 | U206 | X | 1 (0.45) |
| Glycidylaldehyde | 765344 | Oxiranecarboxyaldehyde | 1* | 4 | U126 | A | 10 (4.54) |
| Guanidien, N-methyl-N'-nitro-N-nitroso- | 70257 | MNNG | 1* | 4 | U163 | A | 10 (4.54) |
| Guthion | 865500 | | 1 | 1 | | X | 1 (0.454) |
| HALOETHERS | N/A | | 1* | 2 | | | ** |
| HALOMETHANES | N/A | | 1* | 2 | | | ** |
| Heptachlor | 76448 | 4,7-Methano-1H-indene, 1,4,5,6,7,8,8-heptachloro-3a,4,7,7a-tetrahydro- | 1 | 1,2,4 | P059 | X | 1 (0.454) |
| HEPTACHLOR AND METABOLITES | N/A | | 1* | 2 | | | ** |
| Heptachlor epoxide | 1024573 | | 1* | 2 | | X | 1 (0.454) |
| Hexachlorobenzene | 118741 | Benzene, hexachloro- | 1* | 2,4 | U127 | A | 10 (4.54) |
| Hexachlorobutadiene | 87683 | 1,3-Butadiene, 1,1,2,3,4,5-hexachloro- | 1* | 2,4 | U128 | X | 1 (0.454) |
| HEXACHLOROCYCLOHEXANE (all isomers) | 608731 | | 1* | 2 | | | ** |

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| Hexachlorocyclohexane (gammer isomer) | 58899 | Cyclohexane, 1,2,3,4,5,6-hexachloro-, (1alpha,2alpha,3beta,4alpha,5alpha,6beta)-gamma-BHC Lindane | 1 | 1,2,4 | U129 | X | 1 (0.454) |
| Hexachlorocyclopentadiene | 77474 | 1,3-Cyclopentadiene, 1,2,3,4,5,5-hexachloro- | 1 | 1,2,4 | U130 | A | 10 (4.54) |
| Hexachloroethane | 67721 | Ethane, hexachloro- | 1* | 2,4 | U131 | B | 100 (45.4) |
| Hexachlorophene | 70304 | Phenol, 2,2'-methylenebis[3,4,5-trichloro- | 1* | 4 | U132 | B | 100 (45.4) |
| Hexachloropropene | 1888717 | 1-Propene, 1,1,2,3,3,3-hexachloro- | 1* | 4 | U243 | C | 1000 (454) |
| Hexaethyl tetraphosphate | 757584 | Tetraphosphoric acid, hexaethyl ester | 1* | 4 | P062 | B | 100 (45.4) |
| Hydrazine | 302012 | | 1* | 4 | U133 | X | 1 (0.454) |
| Hydrazine, 1,2-diethyl- | 1615801 | N,N'-Diethylhydrazine | 1* | 4 | U086 | A | 10 (4.54) |
| Hydrazine, 1,1-dimethyl- | 57147 | 1,1-Dimethylhydrazine | 1* | 4 | U098 | A | 10 (4.54) |
| Hydrazine, 1,2-dimethyl- | 540738 | 1,2-Dimethylhydrazine | 1* | 4 | U099 | X | 1 (0.454) |
| Hydrazine, 1,2-diphenyl- | 122667 | 1,2-Diphenylhydrazine | 1* | 2,4 | U109 | A | 10 (4.54) |
| Hydrazine, methyl- | 60344 | Methyl hydrazine | 1* | 4 | P068 | A | 10 (4.54) |
| Hydrazinecarbothioamide | 79196 | Thiosemicarbazide | 1* | 4 | P116 | B | 100 (45.4) |
| Hydrochloric acid | 7647010 | Hydrogen chloride | 5000 | 1 | | D | 5000 (2270) |
| Hydrocyanic acid | 74908 | Hydrogen cyanide | 10 | 1,4 | P063 | A | 10 (4.54) |
| Hydrofluoric acid | 7664393 | Hydrogen flouride | 5000 | 1,4 | U134 | B | 100 (45.4) |
| Hydrogen chloride | 7647010 | Hydrochloric acid | 5000 | 1 | | D | 5000 (2270) |
| Hydrogen cyanide | 74908 | Hydrocyanic acid | 10 | 1,4 | P063 | A | 10 (4.54) |
| Hydrogen fluoride | 7664393 | Hydrofluoric acid | 5000 | 1,4 | U134 | B | 100 (45.4) |
| Hydrogen sulfide | 7783064 | Hydrogen sulfide H2S | 100 | 1,4 | U135 | B | 100 (45.4) |
| Hydrogen sulfide H2S | 7783064 | Hydrogen sulfide | 100 | 1,4 | U135 | B | 100 (45.4) |
| Hydroperoxide, 1-methyl-1-phenylathyl- | 80159 | alpha,alpha-Dimethylbenzylhydroperoxide | 1* | 4 | U096 | A | 10 (4.54) |
| 2-Imidazolidinathione | 96457 | Ethylenethiourea | 1* | 4 | U116 | A | 10 (4.54) |
| Indeno(1,2,3-cd)pyrene | 193395 | 1,10-(1,2-Phenylene)pyrene | 1* | 2,4 | U137 | B | 100 (45.4) |
| 1,3-Isobenzofurandione | 85449 | Phthalic anhydride | 1* | 4 | U190 | D | 5000 (2270) |
| Isobutyl alcohol | 78831 | 1-Propanol, 2-methyl- | 1* | 4 | U140 | D | 5000 (2270) |

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| Isodrin | 465736 | 1,4,5,8-Dimethanonaphthalene, 1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro,(1alpha,4alpha,4abeta,5beta,8beta,8abeta)- | 1* | 4 | P060 | X | 1 (0.454) |
| Isophorone | 78591 | | 1* | 2 | | D | 5000 (2270) |
| Isoprene | 78795 | | 1000 | 1 | | B | 100 (45.4) |
| Isopropanolamine dodecylbenzenesulfonate | 42504461 | | 1000 | 1 | | C | 1000 (454) |
| Isosafrole | 120581 | 1,3-Benzodioxole,5-)1-propenyl)- | 1* | 4 | U141 | B | 100 (45.4) |
| 3(2H)-isoxazolone, 5-(aminomethyl)- | 2763964 | Muscimol 5-(Aminomethyl)-3-isoxazolol | 1* | 4 | P007 | C | 1000 (454) |
| Kepone | 143500 | 1,2,4-Metheno-2H-cyclobuta[cd]pentalen-2-one,1,1a,3,3a,4,5,5,5a,5b,6-decachlorooctahydro- | 1 | 1,4 | U142 | X | 1 (0.454) |
| Lasiocarpine | 303344 | 2-Butenoic acid, 2-methyl-, 7[[2,3-dihydroxy-2-(1-methoxyethyl)-3-methyl-1-oxobutoxy]methyl]-2,3,5,7a-tetrahydro-1H-pyrrolizin-1-yl ester, [1S-[1alpha(Z), 7(2S*,3R*), 7aalpha]]- | 1* | 4 | U143 | A | 10 (4.54) |
| Lead†† | 7439921 | | 1* | 2 | U143 | A | 10 (4.54) |
| Lead acetate | 301042 | Acetic acid, lead(2+) salt | 5000 | 1,4 | U144 | | # |
| LEAD AND COMPOUNDS | N/A | | 1* | 2 | | | ** |
| Lead arsenate | 7784409 | | 5000 | 1 | | X | 1 (0.454) |
| | 7645252 | | 5000 | 1 | | X | 1 (0.454) |
| | 10102484 | | 5000 | 1 | | X | 1 (0.454) |
| Lead, bis(acetato-O)tetrahydroxytri | 1335326 | Lead subacetate | 1* | 4 | U146 | B | 100 (45.4) |
| Lead chloride | 7758954 | | 5000 | 1 | | B | 100 (45.4) |
| Lead fluoborate | 13814965 | | 5000 | 1 | | B | 100 (45.4) |
| Lead fluoride | 7783462 | | 1000 | 1 | | B | 100 (45.4) |
| Lead iodide | 10101630 | | 5000 | 1 | | B | 100 (45.4) |
| Lead nitrate | 10099748 | | 5000 | 1 | | B | 100 (45.4) |
| Lead phosphate | 7446277 | Phosphoric acid, lead(2+) salt (2:3) | 1* | 4 | U145 | | # |
| Lead stearate | 7428480 | | 5000 | 1 | | D | # 5000 (2270) |
| | 1072351 | | 5000 | 1 | | D | # 5000 (2270) |

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| | 52652692 | | 5000 | 1 | | D | # 5000 (2270) |
| | 56189094 | | 5000 | 1 | | D | # 5000 (2270) |
| Lead subacetate | 1335326 | Lead, bis(acetato-O)tetrahydroxytri | 1* | 4 | U146 | B | 100 (45.4) |
| Lead sulfate | 15739807 | | 5000 | 1 | | B | 100 (45.4) |
| | 7446142 | | 5000 | 1 | | B | 100 (45.4) |
| | | | 5000 | 1 | | B | 100 (45.4) |
| Lead sulfide | 1314870 | | 5000 | 1 | | D | # 5000 (2270) |
| Lead thiocyanate | 592870 | | 5000 | 1 | | B | 100 (45.4) |
| Lindane | 58899 | Cyclohexane, 1,2,3,4,5,6-hexachloro-, (1alpha,2alpha,3beta,4alpha,5alpha,6beta)-gamma-BHC Hexachlorocyclohexane (gamma isomer) | 1 | 1,2,4 | U129 | X | 1 (0.454) |
| Lithium Chromate | 14307358 | | 1000 | 1 | | A | 10 (4.54) |
| Malathion | 121755 | | 10 | 1 | | B | 100 (45.4) |
| Maleic acid | 110167 | | 5000 | 1 | | D | 5000 (2270) |
| Maleic anhydride | 108316 | 2,5-Furandione | 5000 | 1,4 | U147 | D | 5000 (2270) |
| Maleic hydrazide | 123331 | 3,6-Pyridazinedione, 1,2-dihydro- | 1* | 4 | U148 | D | 5000 (2270) |
| Malononitrile | 109773 | Propanedinitrile | 1* | 4 | U149 | C | 1000 (454) |
| Melphalan | 148823 | L-Phenylalanine, 4-[bis(2-chloroethyl)aminol] | 1* | 4 | U150 | X | 1 (0.454) |
| Mercaptodimethur | 2032657 | | 100 | 1 | | A | 10 (4.54) |
| Mercuric cyanide | 592041 | | 1 | 1 | | X | 1 (0.454) |
| Mercuric nitrate | 10045940 | | 10 | 1 | | A | 10 (4.54) |
| Mercuric sulfate | 7783359 | | 10 | 1 | | A | 10 (4.54) |
| Mercuric thiocyanate | 592858 | | 10 | 1 | | A | 10 (4.54) |
| Mercurous nitrate | 10415755 | | 10 | 1 | | A | 10 (4.54) |
| | 7782867 | | 10 | 1 | | A | 10 (4.54) |
| Mercury | 7439976 | | 1* | 2,3,4 | U151 | X | 1 (0.454) |
| MERCURY AND COMPOUNDS | N/A | | 1* | 2 | | | ** |
| Mercury, (acetate-O)phenyl | 62384 | Phenylmercury acetate | 1* | 4 | P092 | B | 100 (45.4) |
| Mercury fulminate | 628864 | Fulminic acid, mercury(2+)salt | 1* | 4 | P065 | A | 10 (4.54) |

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| Methacrylonitrile | 126987 | 2-Propenenitrile, 2-methyl- | 1* | 4 | U152 | C | 1000 (454) |
| Methanamine, N-methyl- | 124403 | Dimethylamine | 1000 | 1,4 | U092 | C | 1000 (454) |
| Methanamine, N-methyl-N-nitroso- | 62759 | N-Nitrosodimethylamine | 1* | 2,4 | P082 | A | 10 (4.54) |
| Methane, bromo- | 74839 | Methyl bromide | 1* | 2,4 | U029 | C | 1000 (454) |
| Methane, chloro- | 74873 | Methyl chloride | 1* | 2,4 | U045 | B | 100 (45.4) |
| Methane, chloromethoxy- | 107302 | Chloromethyl methyl ether | 1* | 4 | U046 | A | 10 (4.54) |
| Methane, dibromo- | 74953 | Methylene bromide | 1* | 4 | U068 | C | 1000 (454) |
| Methane, dichloro- | 75092 | Methylene chloride | 1* | 2,4 | U080 | C | 1000 (454) |
| Methane, dichlorodifluoro- | 75718 | Dichlorodifluoromethane | 1* | 4 | U075 | D | 5000 (2270) |
| Methane, iodo- | 74884 | Methyl iodide | 1* | 4 | U138 | B | 100 (45.4) |
| Methane, isocyanato- | 624839 | Methyl isocyanate | 1* | 4 | P064 | | ## |
| Methane, oxybis(chloro- | 542881 | Dichloromethyl ether | 1* | 4 | P016 | A | 10 (4.54) |
| Methanesulfonyl chloride, trichloro- | 594423 | Trichloromethanesulfonyl chloride | 1* | 4 | P118 | B | 100 (45.4) |
| Methanesulfonic acid, ethyl ester | 62500 | Ethyl methanesulfonate | 1* | 4 | U119 | X | 1 (0.454) |
| Methane, tetrachloro- | 56235 | Carbon tetrachloride | 5000 | 1,2,4 | U211 | A | 10 (4.54) |
| Methane, tetranitro | 509148 | Tetranitromethane | 1* | 4 | P112 | A | 10 (4.54) |
| Methane, tribromo- | 75252 | Bromoform | 1* | 2,4 | U225 | B | 100 (45.4) |
| Methane, trichloro- | 67663 | Chloroform | 5000 | 1,2,4 | U044 | A | 10 (4.54) |
| Methane, trichlorofluoro | 75694 | Trichloromonofluoromethane | 1* | 4 | U121 | D | 5000 (2270) |
| Methanethiol | 74931 | Methylmercaptan Thiomethanol | 100 | 1,4 | U153 | B | 100 (45.4) |
| 6,9-Methano-2,4,3-benzodioxathiepin, 6,7,8,9,10,10-hexachloro-1,5,5a,6,9,9a-hexahydro-, 3-oxide | 115297 | Endosulfan | 1 | 1,2,4 | P050 | X | 1 (0.454) |
| 1,3,4-Metheno-2H-cyclobuta[cd]pentalen-2-one, 1,1a,3,3a,4,5,5,5a,5b,6-decachlorooctahydro- | 143500 | Kepona | 1 | 1,4 | U142 | X | 1 (0.454) |
| 4,7-Methano-1H-indene, 1,4,5,6,7,8,8-heptachloro-3a,4,7,7a-tetrahydro- | 76448 | Heptachlor | 1 | 1,2,4 | P059 | X | 1 (0.454) |
| 4,7-Methano-1H-indene, 1,2,3,4,5,6,8,8-octachloro-2,3,3a,4,5,5a-hexahydro- | 57749 | Chlordane Chlordane, alpha & gamma isomers Chlordane, technical | 1 | 1,2,4 | U036 | X | 1 (0.454) |
| Methanol | 67561 | Methyl alcohol | 1* | 4 | U154 | D | 5000 (2270) |

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| Methapyrilene | 91805 | 1,2-Ethanediamine, N,N-dimethyl-N'-2-pyridinyl-N'-(2-thienylmethyl)- | 1* | 4 | U155 | D | 5000 (2270) |
| Methomyl | 16752775 | Ethanimidithioic acid, N-[[[(methylamino)carbonyloxy]-, methyl ester | 1* | 4 | P066 | B | 100 (45.4) |
| Methoxychlor | 72435 | Benzene, 1,1'-(2,2,2-trichloroethylidene)bis[4-methoxy- | 1 | 1,4 | U247 | X | 1 (0.454) |
| Methyl alcohol | 67561 | Methanol | 1* | 4 | U154 | D | 5000 (2270) |
| Methyl bromide | 74839 | Methane, bromo- | 1* | 2,4 | U029 | C | 1000 (454) |
| 1-Methylbutadiene | 504609 | 1,3-Pentadiene | 1* | 4 | U186 | B | 100 (45.4) |
| Methyl chloride | 74873 | Methane, chloro- | 1* | 2,4 | U045 | B | 100 (45.4) |
| Methyl chlorocarbonate | 79221 | Carbonochloridic acid, methyl ester Methyl chloroformate | 1* | 4 | U156 | C | 1000 (454) |
| Methyl chloroform | 71556 | Ethane, 1,1,1-trichloro- 1,1,1-Trichloroethane | 1* | 2,4 | U226 | C | 1000 (454) |
| Methyl chloroformate | 79221 | Carbonochloridic acid, methyl ester Methyl chlorocarbonate | 1* | 4 | U156 | C | 1000 (454) |
| 3-Methylcholanthrene | 56495 | Benz[j]aceanthrylene, 1,2-dihydro- 3-methyl- | 1* | 4 | U157 | A | 10 (4.54) |
| 4,4'-Methylenebis(2-chloroaniline) | 101144 | Benzenamine, 4,4'-methylenebis(2-chloro- | 1* | 4 | U158 | A | 10 (4.54) |
| Methylene bromide | 74953 | Methane, dibromo- | 1* | 4 | U068 | C | 1000 (454) |
| Methylene chloride | 75092 | Methane, dichloro- | 1* | 2,4 | U080 | C | 1000 (454) |
| Methyl ethyl ketone (MEK) | 78933 | 2-Butanone | 1* | 4 | U159 | D | 5000 (2270) |
| Methyl ethyl ketone peroxide | 1338234 | 2-Butanone peroxide | 1* | 4 | U160 | A | 10 (4.54) |
| Methyl hydrazine | 60344 | Hydrazine, methyl- | 1* | 4 | P068 | A | 10 (4.54) |
| Methyl iodide | 74884 | Methane, iodo- | 1* | 4 | U138 | B | 100 (45.4) |
| Methyl isobutyl ketone | 108101 | 4-Methyl-2-pentanone | 1* | 4 | U161 | D | 5000 (2270) |
| Methyl isocyanate | 624839 | Methane, isocyanato- | 1* | 4 | P064 | | ## |
| 2-Methylfalconitrile | 75865 | Acetone cyanohydrin Propanenitrile, 2-hydroxy-2-methyl- | 10 | 1,4 | P069 | A | 10 (4.54) |
| Methylmercaptan | 74931 | Methanethiol Thiomethanol | 100 | 1,4 | U153 | B | 100 (45.4) |
| Methyl methacrylate | 80626 | 2-Propenoic acid, 2-methyl, methyl ester | 5000 | 1,4 | U162 | C | 1000 (454) |
| Methyl parathion | 298000 | Phosphorothioic acid, (,)-dimethyl O-(4-nitro-phenyl) ester | 100 | 1,4 | P071 | B | 100 (45.4) |
| 4-Methyl-2-pentanone | 108101 | Methyl isobutyl ketone | 1* | 4 | U161 | D | 5000 (2270) |

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| Methylthiouracil | 56042 | 4(1H)-Pyrimidinone, 2,3-dihydro-6-methyl-2-thioxo- | 1* | 4 | U164 | A | 10 (4.54) |
| Mevinphos | 7786347 | | 1 | 1 | | A | 10 (4.54) |
| Mexacarbate | 315184 | | 1000 | 1 | | C | 1000 (454) |
| Mitomycin C | 50077 | Azirino[2',3':3,4]pyrrolo[1,2-a]indole-4,7-dione,6-amino-8-[[[aminocarbonyl]oxy]methyl]-1,1a,2,8,8a,8b-hexahydro-8a-methoxy-5-methyl, [1aS-(1aalpha, 8beta,8alpha, 8balpha)]- | 1* | 4 | U010 | A | 10 (4.54) |
| MNNG | 70257 | Guanidine, N-methyl-N'-nitro-N-nitroso- | 1* | 4 | U163 | A | 10 (4.54) |
| Monoethylamine | 75047 | | 1000 | 1 | | B | 100 (45.4) |
| Monomethylamine | 74895 | | 1000 | 1 | | B | 100 (45.4) |
| Multi Source Leachate | | | 1* | 4 | F039 | X | 1 (0.454) |
| Muscimol | 2763964 | 3(2H)-isoxazolone, 5-(aminomethyl)- 5-(Amino-methyl)-3-isoxazolol | 1* | 4 | P007 | C | 1000 (454) |
| Naled | 300765 | | 10 | 1 | | A | 10 (4.54) |
| 5,12-Naphthacenedione, 8-acetyl-10-[3-amino-2,3,6-trideoxy-alpha-L-lyxo-hexopyranosyl]oxy]-7,8,9,10-tetrahydro-6,8,11-trihydroxy-1-methoxy, (8S-cis)- | 20830813 | Daunomycin | 1* | 4 | U059 | A | 10 (4.54) |
| 1-Naphthalenamine | 134327 | alpha-Naphthylamine | 1* | 4 | U167 | B | 100 (45.4) |
| 2-Naphthalenamine | 91598 | beta-Naphthylamine | 1* | 4 | U168 | A | 10 (4.54) |
| Naphthalenamine,N,N'-bis(2-chloroethyl)- | 494031 | Chlornaphazine | 1* | 4 | U026 | B | 100 (45.4) |
| Naphthalene | 91203 | | 5000 | 1,2,4 | U165 | B | 100 (45.4) |
| Naphthalene, 2-chloro- | 91587 | beta-Chloronaphthalene 2-Chloronaphthalene | 1* | 2,4 | U047 | D | 5000 (2270) |
| 1,4-Naphthalenedione | 130154 | 1,4-Naphthoquinone | 1* | 4 | U166 | D | 5000 (2270) |
| 2,7-Naphthalenedisulfonic acid; 3,3'-[(3,3'-dimethyl-(1,1'-byphenyl)-4,4'-diyl)-bis(azo)]bis(5-amino-4-hydroxy)tetrasodium salt | 72571 | Trypan blue | 1* | 4 | U236 | A | 10 (4.54) |
| Naphthenic acid | 1338245 | | 100 | 1 | | B | 100 (45.4) |
| 1,4-Naphthoquinone | 130154 | 1,4-Naphthalenedione | 1* | 4 | U166 | D | 5000 (2270) |
| alpha-Naphthylamine | 134327 | 1,-Naphthalenamine | 1* | 4 | U167 | B | 100 (45.4) |
| beta-Naphthylamine | 91598 | 2,-Naphthalenamine | 1* | 4 | U168 | A | 10 (4.54) |

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| alpha-Naphthylthiourea | 86884 | Thiourea, 1-naphthalenyl- | 1* | 4 | P072 | B | 100 (45.4) |
| Nickel†† | 7440020 | | 1* | 2 | | B | 100 (45.4) |
| Nickel ammonium sulfate | 15699180 | | 5000 | 1 | | B | 100 (45.4) |
| NICKEL AND COMPOUNDS | N/A | | 1* | 2 | | | ** |
| Nickel carbonyl | 13463393 | Nickel carbonyl Ni(CO)4, (T-4)- | 1* | 4 | P073 | A | 10 (4.54) |
| Nickel carbonyl Ni(CO)4, (T-4)- | 13463393 | Nickel carbonyl | 1* | 4 | P073 | A | 10 (4.54) |
| Nickel chloride | 7718549 | | 5000 | 1 | | B | 100 (45.4) |
| | 37211055 | | 5000 | 1 | | B | 100 (45.4) |
| Nickel cyanide | 557197 | Nickel cyanide Ni(CN)2 | 1* | 4 | P074 | A | 10 (4.54) |
| Nickel cyanide Ni(CN)2 | 557197 | Nickel cyanide | 1* | 4 | P074 | A | 10 (4.54) |
| Nickel hydroxide | 12054487 | | 1000 | 1 | | A | 10 (4.54) |
| Nickel nitrate | 14216752 | | 5000 | 1 | | B | 100 (45.4) |
| Nickel sulfate | 7786814 | | 5000 | 1 | | B | 100 (45.4) |
| Nicotine, & salts | 54115 | Pyridine, 3-(1-methyl-2-pyrrolidinyl)-, (S)- | 1* | 4 | P075 | B | 100 (45.4) |
| Nitric acid | 7697372 | | 1000 | 1 | | C | 1000 (454) |
| Nitric acid, thallium (1+) salt | 10102451 | Thallium (I) nitrate | 1* | 4 | U217 | B | 100 (45.4) |
| Nickel oxide | 10102439 | Nitrogen oxide NO | 1* | 4 | P076 | A | 10 (4.54) |
| p-Nitroaniline | 100016 | Benzenamine, 4-nitro- | 1* | 4 | P077 | D | 5000 (2270) |
| Nitrobenzene | 98953 | Benzene, nitro- | 1000 | 1,2,4 | U169 | C | 1000 (454) |
| Nitrogen dioxide | 10102440 | Nitrogen oxide NO2 | 1000 | 1,4 | P078 | A | 10 (4.54) |
| | 10544726 | | 1000 | 1,4 | P078 | A | 10 (4.54) |
| Nitrogen oxide NO | 10102439 | Nitric oxide | 1* | 4 | P076 | A | 10 (4.54) |
| Nitrogen oxide NO2 | 10102440 | Nitrogen dioxide | 1000 | 1,4 | P078 | A | 10 (4.54) |
| | 10544726 | | | | | | |
| Nitroglycerine | 55630 | 1,2,3-Propanetriol, trinitrate- | 1* | 4 | P081 | A | 10 (4.54) |
| Nitrophenol (mixed) | 25154556 | | 1000 | 1 | | B | 100 (45.4) |
| m-Nitrophenol | 554847 | | | | | B | 100 (45.4) |
| o-Nitrophenol | 88755 | 2-Nitrophenol | | | | | |
| p-Nitrophenol | 100027 | Phenol, 4-nitro-4-Nitrophenol | | | | | |
| o-Nitrophenol | 88755 | 2-Nitrophenol | 1000 | 1,2 | | B | 100 (45.4) |
| p-Nitrophenol | 100027 | Phenol, 4-nitro- 4-Nitrophenol | 1000 | 1,2,4 | U170 | B | 100 (45.4) |

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| 2-Nitrophenol | 88755 | o-Nitrophenol | 1000 | 1,2 | | B | 100 (45.4) |
| 4-Nitrophenol | 100027 | p-Nitrophenol Phenol, 4-nitro- | 1000 | 1,2,4 | U170 | B | 100 (45.4) |
| NITROPHENOLS | N/A | | 1* | 2 | | | ** |
| 2-Nitropropane | 79469 | Propane, 2-nitro- | 1* | 4 | U171 | A | 10 (4.54) |
| NITROSAMINES | N/A | | 1* | 2 | | | ** |
| N-Nitrosodi-n-butylamine | 924163 | 1-Butanamine, N-butyl-N-nitroso- | 1* | 4 | U172 | A | 10 (4.54) |
| N-Nitrosodiethanolamine | 1116547 | Ethanol, 2,2'-(nitrosoimino)bis- | 1* | 4 | U173 | X | 1 (0.454) |
| N-Nitrosodiethylamine | 55185 | Ethanamine, N-ethyl-N-nitroso- | 1* | 4 | U174 | X | 1 (0.454) |
| N-Nitrosodimethylamine | 62759 | Methanamine, N-methyl-N-nitroso- | 1* | 2,4 | P082 | A | 10 (4.54) |
| N-Nitrosodiphenylamine | 86306 | | 1* | 2 | | B | 100 (45.4) |
| N-Nitroso-N-ethylurea | 759739 | Urea, N-ethyl-N-nitroso- | 1* | 4 | U176 | X | 1 (0.454) |
| N-Nitroso-N-methylurea | 684935 | Urea, N-methyl-N-nitroso | 1* | 4 | U177 | X | 1 (0.454) |
| N-Nitroso-N-methylurethane | 615532 | Carbamic acid, methylnitroso-, ethyl ester | 1* | 4 | U178 | X | 1 (0.454) |
| N-Nitrosomethylvinylamine | 4549400 | Vinylamine, N-methyl-N-nitroso- | 1* | 4 | P084 | A | 10 (4.54) |
| N-Nitrosopiperidine | 100754 | Piperidine, 1-nitroso- | 1* | 4 | U179 | A | 10 (4.54) |
| N-Nitrosopyrrolidine | 930552 | Pyrrolidine, 1-nitroso- | 1* | 4 | U180 | X | 1 (0.454) |
| Nitrotoluene | 1321126 | | 1000 | 1 | | C | 1000 (454) |
| m-Nitrotoluene | 99081 | | | | | | |
| o-Nitrotoluene | 88722 | | | | | | |
| p-Nitrotoluene | 99990 | | | | | | |
| 5-Nitro-o-toluidine | 99558 | Benzenamine, 2-methyl-5-nitro- | 1* | 4 | U181 | B | 100 (45.4) |
| Octamethylpyrophosphoramidate | 152169 | Diphosphoramidate, octamethyl- | 1* | 4 | P085 | B | 100 (45.4) |
| Osmium oxide OsO4 (T-4)- | 20816120 | Osmium tetroxide | 1* | 4 | P087 | C | 1000 (454) |
| Osmium tetroxide | 20816120 | Osmium oxide OsO4 (T-4)- | 1* | 4 | P087 | C | 1000 (454) |
| 7-Oxabicyclo[2.2.1]heptane-2,3-dicarboxylic acid | 145733 | Endothall | 1* | 4 | P088 | C | 1000 (454) |
| 1,2-Oxathiolane, 2,2-dioxide | 1120714 | 1,3-Propane sultone | 1* | 4 | U193 | A | 10 (4.54) |
| 2H-1,3,2-Oxazaphosphorin-2-amine, N,N-bis(2-chloroethyl) tetrahydro-, 2-oxide | 50180 | Cyclophosphamide | 1* | 4 | U058 | A | 10 (4.54) |
| Oxirane | 75218 | Ethylene oxide | 1* | 4 | U115 | A | 10 (4.54) |
| Oxiranecarboxyaldehyde | 765344 | Glycidylaldehyde | 1* | 4 | U126 | A | 10 (4.54) |

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| Oxirane, (chloromethyl)- | 106898 | Epichlorohydrin | 1000 | 1,4 | U041 | B | 100 (45.4) |
| Paraformaldehyde | 30525894 | | 1000 | 1 | | C | 1000 (454) |
| Paraldehyde | 123637 | 1,3,5-Trioxane, 2,4,6-trimethyl- | 1* | 4 | U182 | C | 1000 (454) |
| Parathion | 56382 | Phosphorothioic acid, O,O-diethyl O-(4-nitrophenyl) ester | 1 | 1,4 | P089 | A | 10 (4.54) |
| Pentachlorobenzene | 608935 | Benzene, pentachloro- | 1* | 4 | U183 | A | 10 (4.54) |
| Pentachloroethane | 76017 | Ethane, pentachloro- | 1* | 4 | U184 | A | 10 (4.54) |
| Pentachloronitrobenzene (PCNB) | 82688 | Benzene, pentachloronitro- | 1* | 4 | U185 | B | 100 (45.4) |
| Pentachlorophenol | 87865 | Phenol, pentachloro- | 10 | 1,2,4 | U242 | A | 10 (4.54) |
| 1,3-Pentadiene | 504609 | 1-Methylbutadiene | 1* | 4 | U186 | B | 100 (45.4) |
| Perchloroethylene | 127184 | Ethene, tetrachloro- Tetrachloro-ethene Tetrachloro-ethylene | 1* | 2,4 | U210 | B | 100 (45.4) |
| Phenacetin | 62442 | Acetamide, N-(4-ethoxyphenyl)- | 1* | 4 | U187 | B | 100 (45.4) |
| Phenanthrene | 85018 | | 1* | 2 | | D | 5000 (2270) |
| Phenol | 108952 | Benzene, hydroxy- | 1000 | 1,2,4 | U188 | C | 1000 (454) |
| Phenol, 2-chloro- | 95578 | o-Chlorophenol 2-Chlorophenol | 1* | 2,4 | U048 | B | 100 (45.4) |
| Phenol, 4-chloro-3-methyl- | 59507 | p-Chloro-m-cresol 4-Chloro-m-cresol | 1* | 2,4 | U039 | D | 5000 (2270) |
| Phenol, 2-cyclohexyl-4,6-dinitro- | 131895 | 2-Cyclohexyl-4,6-dinitrophenol | 1* | 4 | P034 | B | 100 (45.4) |
| Phenol, 2,4-dichloro- | 120832 | 2,4-Dichlorophenol | 1* | 2,4 | U081 | B | 100 (45.4) |
| Phenol, 2,6-dichloro | 87650 | 2,6-Dichlorophenol | 1* | 4 | U082 | B | 100 (45.4) |
| Phenol, 4,4'-(1,2-diethyl-1,2-ethenediyl)bis-, (E) | 56531 | Diethylstilbestrol | 1* | 4 | U089 | X | 1 (0.454) |
| Phenol, 2,4-dimethyl- | 105679 | 2,4-Dimethylphenol | 1* | 2,4 | U101 | B | 100 (45.4) |
| Phenol, 2,4-dinitro- | 51285 | 2,4-Dinitrophenol | 1000 | 1,2,4 | P048 | A | 10 (4.54) |
| Phenol, methyl- | 1319773 | Cresol(s) Cresylic acid | 1000 | 1,4 | U052 | C | 1000 (454) |
| m-Cresol | 108394 | m-Cresylic acid | 1000 | 1,4 | U052 | C | 1000 (454) |
| o-Cresol | 95487 | o-Cresylic acid | 1000 | 1,4 | U052 | C | 1000 (454) |
| p-Cresol | 106445 | p-Cresylic acid | 1000 | 1,4 | U052 | C | 1000 (454) |
| Phenol, 2-methyl-4,6-dinitro- | 534521 | 4,6-Dinitro-o-cresol and salts | 1* | 2,4 | P047 | A | 10 (4.54) |
| Phenol, 2,2'-methylenebis[3,4,6-trichloro- | 70304 | Hexachlorophene | 1* | 4 | U132 | B | 100 (45.4) |
| Phenol, 2-(1-methylpropyl)-4,6-dinitro | 88857 | Dinoseb | 1* | 4 | P020 | C | 1000 (454) |

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| Phenol, 4-nitro- | 100027 | p-Nitrophenol 4-Nitrophenol | 1000 | 1,2,4 | U170 | B | 100 (45.4) |
| Phenol, pentachloro- | 87865 | Pentachlorophenol | 10 | 1,2,4 | U242 | A | 10 (4.54) |
| Phenol, 2,3,4,6-tetrachloro- | 58902 | 2,3,4,6-Tetrachlorophenol | 1* | 4 | U212 | A | 10 (4.54) |
| Phenol, 2,4,5-trichloro- | 95954 | 2,4,5-Trichlorophenol | 10 | 1,4 | U230 | A | 10 (4.54) |
| Phenol, 2,4,6-trichloro- | 88062 | 2,4,6-Trichlorophenol | 10 | 1,2,4 | U231 | A | 10 (4.54) |
| Phenol, 2,4,6-trinitro-, ammonium salt | 131748 | Ammonium picrate | 1* | 4 | P009 | A | 10 (4.54) |
| L-Phenylalanine, 4-[bis(2-chloroethyl) amino] | 148823 | Melphalan | 1* | 4 | U150 | X | 1 (0.454) |
| 1,10-(1,2-Phenylene)pyrene | 193395 | Indeno(1,2,3-cd)pyrene | 1* | 2,4 | U137 | B | 100 (45.4) |
| Phenylmercury acetate | 62384 | Mercury, (acetato-O)phenyl- | 1* | 4 | P092 | B | 100 (45.4) |
| Phenylthiourea | 103855 | Thiourea, phenyl- | 1* | 4 | P093 | B | 100 (45.4) |
| Phorate | 298022 | Phosphorodithioic acid, O,O-diethyl S-(ethylthio), methyl ester | 1* | 4 | P094 | A | 10 (4.54) |
| Phosgene | 75445 | Carbonic dichloride | 5000 | 1,4 | P095 | A | 10 (4.54) |
| Phosphine | 7803512 | | 1* | 4 | P096 | B | 100 (45.4) |
| Phosphoric acid | 7664382 | | 5000 | 1 | | D | 5000 (2270) |
| Phosphoric acid, diethyl 4-nitrophenyl ester | 311455 | Diethyl-p-nitrophenyl phosphate | 1* | 4 | P041 | B | 100 (45.4) |
| Phosphoric acid, lead(2+) salt (2:3) | 7446277 | Lead phosphate | 1* | 4 | U145 | | # |
| Phosphorodithioic acid, O,O-diethyl S-[2-(ethylthio)ethyl]ester | 298044 | Disulfoton | 1 | 1,4 | P039 | X | 1 (0.454) |
| Phosphorodithioic acid, O,O-diethyl S-(ethylthio), methyl ester | 298022 | Phorate | 1* | 4 | P094 | A | 10 (4.54) |
| Phosphorodithioic acid, O,O-diethyl S-methyl ester | 3288582 | O,O-Diethyl S-methyl dithiophosphate | 1* | 4 | U087 | D | 5000 (2270) |
| Phosphorodithioic acid, O,O-dimethyl S-[2(methylamino)-2-oxoethyl] ester | 60515 | Dimethoate | 1* | 4 | P044 | A | 10 (4.54) |
| Phosphorofluoridic acid, bis(1-methylethyl) ester | 55914 | Diisopropylfluorophosphate | 1* | 4 | P043 | B | 100 (45.4) |
| Phosphorothioic acid, O,O-diethyl O-(4-nitrophenyl) ester | 56382 | Parathion | 1 | 1,4 | P089 | A | 10 (4.54) |
| Phosphorothioic acid, O,[4-[(dimethylamino)sulfonyl]phenyl]O,O-dimethyl ester | 52857 | Famphur | 1* | 4 | P097 | C | 1000 (454) |

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| Phosphorothioic acid, O,O-dimethyl O-(4-nitrophenyl) ester | 298000 | Methyl parathion | 100 | 1,4 | P071 | B | 100 (45.4) |
| Phosphorothioic acid, O,O-diethyl O-pyrazinyl phosphorothioate | 297972 | O,O-Diethyl O-pyrazinyl phosphorothioate | 1* | 4 | P040 | B | 100 (45.4) |
| Phosphorus | 7723140 | | 1 | 1 | | X | 1 (0.454) |
| Phosphorus oxycloride | 10025873 | | 5000 | 1 | | C | 1000 (454) |
| Phosphorus pentasulfide | 1314803 | Phosphorus sulfide Sulfur phosphide | 100 | 1,4 | U189 | B | 100 (45.4) |
| Phosphorus sulfide | 1314803 | Phosphorus pentasulfide Sulfur phosphide | 100 | 1,4 | U189 | B | 100 (45.4) |
| Phosphorus trichloride | 7719122 | | 5000 | 1 | | C | 1000 (454) |
| PHTHALATE ESTERS | N/A | | 1* | 2 | | | ** |
| Phthalic anhydride | 85449 | 1,3-Isobenzofurandione | 1* | 4 | U190 | D | 5000 (2270) |
| 2-Picoline | 109068 | Pyridine, 2-methyl- | 1* | 4 | U191 | D | 5000 (2270) |
| Piperidine, 1-nitroso- | 100754 | N-Nitrosopiperidine | 1* | 4 | U179 | A | 10 (4.54) |
| Plumbane, tetraethyl- | 78002 | Tetraethyl lead | 100 | 1,4 | P110 | A | 10 (4.54) |
| POLYCHLORINATED BIPHENYLS (PCBs) | 1336363 | | 10 | 1,2 | | X | 1 (0.454) |
| Aroclor 1016 | 12674112 | POLYCHLORINATED BIPHENYLS (PCBs) | | | | | |
| Aroclor 1221 | 11104282 | POLYCHLORINATED BIPHENYLS (PCBs) | | | | | |
| Aroclor 1232 | 11141165 | POLYCHLORINATED BIPHENYLS (PCBs) | | | | | |
| Aroclor 1242 | 53469219 | POLYCHLORINATED BIPHENYLS (PCBs) | | | | | |
| Aroclor 1248 | 12672296 | POLYCHLORINATED BIPHENYLS (PCBs) | | | | | |
| Aroclor 1254 | 11097691 | POLYCHLORINATED BIPHENYLS (PCBs) | | | | | |
| Aroclor 1260 | 11096825 | POLYCHLORINATED BIPHENYLS (PCBs) | | | | | |
| POLYNUCLEAR AROMATIC HYDROCARBONS | N/A | | 1* | 2 | | | ** |
| Potassium arsenate | 7784410 | | 1000 | 1 | | X | 1 (0.454) |
| Potassium arsenite | 10124502 | | 1000 | 1 | | X | 1 (0.454) |
| Potassium bichromate | 7778509 | | 1000 | 1 | | A | 10 (4.54) |
| Potassium chromate | 7789006 | | 1000 | 1 | | A | 10 (4.54) |

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| Potassium cyanide | 151508 | Potassium cyanide K (CN) | 10 | 1,4 | P098 | A | 10 (4.54) |
| Potassium cyanide K(CN) | 151508 | Potassium cyanide | 10 | 1,4 | P098 | A | 10 (4.54) |
| Potassium hydroxide | 1310583 | | 1000 | 1 | | C | 1000 (454) |
| Potassium permanganate | 7722647 | | 100 | 1 | | B | 100 (45.4) |
| Potassium silver cyanide | 506616 | Argentate (1-), bis(cyano-C)-, potassium | 1* | 4 | P099 | X | 1 (0.454) |
| Pronamide | 23950585 | Benzamide, 3,5-dichloro-N-(1,1-dimethyl-2-propynyl)- | 1* | 4 | U192 | D | 5000 (2270) |
| Propanal, 2-methyl-2-(methylthio)-, O-[(methylamino)carbonyl]oxime | 116063 | Aldicarb | 1* | 4 | P070 | X | 1 (0.454) |
| 1-Propanamine | 107108 | n-Propylamine | 1* | 4 | U194 | D | 5000 (2270) |
| 1-Propanamine, N-propyl- | 142847 | Dipropylamine | 1* | 4 | U110 | D | 5000 (2270) |
| 1-Propanamine, N-nitroso-N-propyl- | 621647 | Di-n-propylnitrosamine | 1* | 2,4 | U111 | A | 10 (4.54) |
| Propane, 1,2-dibromo-3-chloro- | 96128 | 1,2-Dibromo-3-chloropropane | 1* | 4 | U066 | X | 1 (0.454) |
| Propane, 2-nitro- | 79469 | 2-Nitropropane | 1* | 4 | U171 | A | 10 (4.54) |
| 1,3-Propane sultone | 1120714 | 1,2-Oxathiolane, 2,2-dioxide | 1* | 4 | U193 | A | 10 (4.54) |
| Propane, 1,2-dichloro- | 78875 | Propylene dichloride 1,2-Dichloropropane | 5000 | 1,2,4 | U083 | C | 1000 (454) |
| Propanedinitrile | 109773 | Malononitrile | 1* | 4 | U149 | C | 1000 (454) |
| Propanenitrile | 107120 | Ethyl cynide | 1* | 4 | P101 | A | 10 (4.54) |
| Propanenitrile, 3-chloro- | 542767 | 3-Chloropropionitrile | 1* | 4 | P027 | C | 1000 (454) |
| Propanenitrile, 2-hydroxy-2-methyl- | 75865 | Acetone cyanohydrin 2-Methylactonitrile | 10 | 1,4 | P069 | A | 10 (4.54) |
| Propane, 2,2'-oxybis[2-chloro- | 108601 | Dichloroisopropyl ether | 1* | 2,4 | U027 | C | 1000 (454) |
| 1,2,3-Propanetriol, trinitrate- | 55630 | Nitroglycerine | 1* | 4 | P081 | A | 10 (4.54) |
| 1-Propanol, 2,3-dibromo-, phosphate (3:1) | 126727 | Tris(2,3-dibromopropyl) phosphate | 1* | 4 | U235 | A | 10 (4.54) |
| 1-Propanol, 2-methyl- | 78831 | Isobutyl alcohol | 1* | 4 | U140 | D | 5000 (2270) |
| 2-Propanone | 67641 | Acetone | 1* | 4 | U002 | D | 5000 (2270) |
| 2-Propanone, 1-bromo- | 598312 | Bromoacetone | 1* | 4 | P017 | C | 1000 (454) |
| Propargite | 2312358 | | 10 | 1 | | A | 10 (4.54) |
| Propargyl alcohol | 107197 | 2-Propyn-1-ol | 1* | 4 | P102 | C | 1000 (454) |
| 2-Propenal | 107028 | Acrolein | 1 | 1,2,4 | P003 | X | 1 (0.454) |
| 2-Propenamide | 79061 | Acrylamide | 1* | 4 | U007 | D | 5000 (2270) |

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| 1-Propene, 1,1,2,3,3,3-hexachloro- | 1888717 | Hexachloropropene | 1* | 4 | U243 | C | 1000 (454) |
| 1-Propene, 1,3-dichloro- | 542756 | 1,3-Dichloropropene | 5000 | 1,2,4 | U084 | B | 100 (45.4) |
| 2-Propenenitrile | 107131 | Acrylonitrile | 100 | 1,2,4 | U009 | B | 100 (45.4) |
| 2-Propenenitrile, 2-methyl- | 126987 | Methacrylonitrile | 1* | 4 | U152 | C | 1000 (454) |
| 2-Propenoic acid | 79107 | Acrylic acid | 1* | 4 | U008 | D | 5000 (2270) |
| 2-Propenoic acid, ethyl ester | 140885 | Ethyl acrylate | 1* | 4 | U113 | C | 1000 (454) |
| 2-Propenoic acid, 2-methyl-, ethyl ester | 97632 | Ethyl methacrylate | 1* | 4 | U118 | C | 1000 (454) |
| 2-Propenoic acid, 2-methyl-, methyl ester | 80626 | Methyl methacrylate | 5000 | 1,4 | U162 | C | 1000 (454) |
| 2-Propen-1-ol | 107186 | Allyl alcohol | 100 | 1,4 | P005 | B | 100 (45.4) |
| Propionic acid | 79094 | | 5000 | 1 | | D | 5000 (2270) |
| Propionic acid, 2-(2,4,5-trichlorophenoxy)- | 93721 | Silvex (2,4,5-TP) 2,4,5-TP acid | 100 | 1,4 | U233 | B | 100 (45.4) |
| Propionic anhydride | 123626 | | 5000 | 1 | | D | 5000 (2270) |
| n-Propylamine | 107108 | 1-Propanamine | 1* | 4 | U194 | D | 5000 (2270) |
| Propylene dichloride | 78875 | Propane, 1,2-dichloro- 1,2-Dichloropropane | 5000 | 1,2,4 | U083 | C | 1000 (454) |
| Propylene oxide | 75569 | | 5000 | 1 | | B | 100 (45.4) |
| 1,2-Propylenimine | 75558 | Aziridine, 2-methyl- | 1* | 4 | P067 | X | 1 (0.454) |
| 2-Propyn-1-ol | 107197 | Propargyl alcohol | 1* | 4 | P102 | C | 1000 (454) |
| Pyrene | 129000 | | 1* | 2 | | D | 5000 (2270) |
| Pyrethrins | 121299 | | 1000 | 1 | | X | 1 (0.454) |
| | 121211 | | 1000 | 1 | | X | 1 (0.454) |
| | 8003347 | | 1000 | 1 | | X | 1 (0.454) |
| 3,6-Pyridazinedione, 1,2-dihydro- | 123331 | Maleic hydrazide | 1* | 4 | U148 | D | 5000 (2270) |
| 4-Pyridinamine | 504245 | 4-Aminopyridine | 1* | 4 | P008 | C | 1000 (454) |
| Pyridine | 110861 | | 1* | 4 | U196 | C | 1000 (454) |
| Pyridine, 2-methyl- | 109068 | 2-Picoline | 1* | 4 | U191 | D | 5000 (2270) |
| Pyridine, 3-(1-methyl-2-pyrrolidinyl)-, (S) | 54115 | Nicotine, & salts | 1* | 4 | P075 | B | 100 (45.4) |
| 2,4-(1H,3H)-Pyrimidinedione, 5-[bis(2-chloroethyl)amino]- | 66751 | Uracil mustard | 1* | 4 | U237 | A | 10 (4.54) |
| 4(1H)-Pyrimidinone, 2,3-dihydro-6-methyl-2-thioxo- | 56042 | Methylthiouracil | 1* | 4 | U164 | A | 10 (4.54) |

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| Pyrrolidine, 1-nitroso- | 930552 | N-Nitrosopyrrolidine | 1* | 4 | U180 | X | 1 (0.454) |
| Quinoline | 91225 | | 1000 | 1 | | D | 5000 (2270) |
| RADIONUCLIDES | N/A | | 1* | 3 | | | 5 |
| Reserpine | 50555 | Yohimban-16-carboxylic acid, 11,17-dimethoxy-18-[(3,4,5-trimethoxybenzoyl)oxy-, methyl ester (3beta, 16beta, 17alpha, 18beta, 20alpha)- | 1* | 4 | U200 | D | 5000 (2270) |
| Resorcinol | 108463 | 1,3-Benzenediol | 1000 | 1,4 | U201 | D | 5000 (2270) |
| Saccharin and salts | 81072 | 1,2-Benzisothiazol-3(2H)-one, 1,1-dioxide | 1* | 4 | U202 | B | 100 (45.4) |
| Safrole | 94597 | 1,3-Benzodioxole, 5-(2-propenyl)- | 1* | 4 | U203 | B | 100 (45.4) |
| Selenious acid | 7783008 | | 1* | 4 | U204 | A | 10 (4.54) |
| Selenious acid, dithallium (1+) salt | 12039520 | Thallium selenite | 1* | 4 | P114 | C | 1000 (454) |
| Selenium†† | 7782492 | | 1* | 2 | | B | 100 (45.4) |
| SELENIUM AND COMPOUNDS | N/A | | 1* | 2 | | | ** |
| Selenium dioxide | 7446084 | Selenium oxide | 1000 | 1,4 | U204 | A | 10 (4.54) |
| Selenium oxide | 7446084 | Selenium dioxide | 1000 | 1,4 | U204 | A | 10 (4.54) |
| Selenium sulfide | 7488564 | Selenium sulfide SeS2 | 1* | 4 | U205 | A | 10 (4.54) |
| Selenium sulfide SeS2 | 7488564 | Selenium sulfide | 1* | 4 | U205 | A | 10 (4.54) |
| Selenourea | 630104 | | 1* | 4 | P103 | C | 1000 (454) |
| L-Serine, diazoacetate (ester) | 115026 | Azaserine | 1* | 4 | U015 | X | 1 (0.454) |
| Silver†† | 7440224 | | 1* | 2 | | C | 1000 (454) |
| SILVER AND COMPOUNDS | N/A | | 1* | 2 | | | ** |
| Silver cyanide | 506649 | Silver cyanide Ag(CN) | 1* | 4 | P104 | X | 1 (0.454) |
| Silver cyanide Ag (CN) | 506649 | Silver cyanide | 1* | 4 | P104 | X | 1 (0.454) |
| Silver nitrate | 7761888 | | 1 | 1 | | X | 1 (0.454) |
| Silvex (2,4,5-TP) | 93721 | Propionic acid, 2-(2,4,5-trichlorophenoxy)-2,4,5-TP acid | 100 | 1,4 | U233 | B | 100 (45.4) |
| Sodium | 7440235 | | 1000 | 1 | | A | 10 (4.54) |
| Sodium arsenate | 7631892 | | 1000 | 1 | | X | 1 (0.454) |
| Sodium arsenite | 7784465 | | 1000 | 1 | | X | 1 (0.454) |
| Sodium azide | 26628228 | | 1* | 4 | P105 | C | 1000 (454) |
| Sodium bichromate | 10588019 | | 1000 | 1 | | A | 10 (4.54) |

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| Sodium bifluoride | 1333831 | | 5000 | 1 | | B | 100 (45.4) |
| Sodium bisulfite | 7631905 | | 5000 | 1 | | D | 5000 (2270) |
| Sodium chromate | 7775113 | | 1000 | 1 | | A | 10 (4.54) |
| Sodium cyanide | 143339 | Sodium cyanide Na(CN) | 10 | 1,4 | P106 | A | 10 (4.54) |
| Sodium cyanide Na (CN) | 143339 | Sodium cyanide | 10 | 1,4 | P106 | A | 10 (4.54) |
| Sodium dodecylbenzenesulfonate | 25155300 | | 1000 | 1 | | C | 1000 (454) |
| Sodium fluoride | 7681494 | | 5000 | 1 | | C | 1000 (454) |
| Sodium hydrosulfide | 16721805 | | 5000 | 1 | | D | 5000 (2270) |
| Sodium hydroxide | 1310732 | | 1000 | 1 | | C | 1000 (454) |
| Sodium hypochlorite | 7681529 | | 100 | 1 | | B | 100 (45.4) |
| | 10022705 | | 100 | 1 | | B | 100 (45.4) |
| Sodium methylate | 124414 | | 1000 | 1 | | C | 1000 (454) |
| Sodium nitrite | 7632000 | | 100 | 1 | | B | 100 (45.4) |
| Sodium phosphate, dibasic | 7558794 | | 5000 | 1 | | D | 5000 (2270) |
| | 10039324 | | 5000 | 1 | | D | 5000 (2270) |
| | 10140655 | | 5000 | 1 | | D | 5000 (2270) |
| Sodium phosphate, tribasic | 7601549 | | 5000 | 1 | | D | 5000 (2270) |
| | 7758294 | | 5000 | 1 | | D | 5000 (2270) |
| | 7785844 | | 5000 | 1 | | D | 5000 (2270) |
| | 10101890 | | 5000 | 1 | | D | 5000 (2270) |
| | 10124568 | | 5000 | 1 | | D | 5000 (2270) |
| | 10361894 | | 5000 | 1 | | D | 5000 (2270) |
| Sodium selenite | 10102188 | | 1000 | 1 | | B | 100 (45.4) |
| | 7782823 | | | | | | |
| Streptozotocin | 18883664 | D-Glucose, 2-deoxy-2- [[[(methylnitrosoamino)-carbonyl] amino]- Glucopyranose, 2-deoxy-2-(3- methyl-3-nitrosoureido)- | 1* | 4 | U206 | X | 1 (0.454) |
| Strontium chromate | 7789062 | | 1000 | 1 | | A | 10 (4.54) |
| Strychnidin-10-one | 57249 | Strychnine, & salts | 10 | 1,4 | P108 | A | 10 (4.54) |
| Strychnidin-10-one, 2,3- dimethoxy- | 357573 | Brucine | 1* | 4 | P018 | B | 100 (45.4) |
| Strychnine, & salts | 57249 | Strychnidin-10-one | 10 | 1,4 | P108 | A | 10 (4.54) |

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| Styrene | 100425 | | 1000 | 1 | | C | 1000 (454) |
| Sulfur monochloride | 12771083 | | 1000 | 1 | | C | 1000 (454) |
| Sulfur phosphide | 1314803 | Phosphorus pentasulfide Phosphorus sulfide | 100 | 1,4 | U189 | B | 100 (45.4) |
| Sulfuric acid | 7664939 | | 1000 | 1 | | C | 1000 (454) |
| | 8014957 | | 1000 | 1 | | C | 1000 (454) |
| Sulfuric acid, dithallium (1+) salt | 7446186 | Thallium (I) sulfate | 1000 | 1,4 | P115 | B | 100 (45.4) |
| | 10031591 | | 1000 | -1,4 | P115 | B | 100 (45.4) |
| Sulfuric acid, dimethyl ester | 77781 | Dimethyl sulfate | 1* | 4 | U103 | B | 100 (45.4) |
| 2,4,5-T acid | 93765 | Acetic acid, (2,4,5-trichlorophenoxy) 2,4,5-T | 100 | 1,4 | U232 | C | 1000 (454) |
| 2,4,5-T amines | 2008460 | | 100 | 1 | | D | 5000 (2270) |
| | 1319728 | | 100 | 1 | | D | 5000 (2270) |
| | 3813147 | | 100 | 1 | | D | 5000 (2270) |
| | 6369966 | | 100 | 1 | | D | 5000 (2270) |
| | 6369977 | | 100 | 1 | | D | 5000 (2270) |
| 2,4,5-T esters | 93798 | | 100 | 1 | | C | 1000 (454) |
| | 1928478 | | 100 | 1 | | C | 1000 (454) |
| | 2545597 | | 100 | 1 | | C | 1000 (454) |
| | 25168154 | | 100 | 1 | | C | 1000 (454) |
| | 61792072 | | 100 | 1 | | C | 1000 (454) |
| 2,4,5-T salts | 13560991 | | 100 | 1 | | C | 1000 (454) |
| 2,4,5-T | 93765 | Acetic acid, (2,4,5-trichlorophenoxy) 2,4,5-T acid | 100 | 1,4 | U232 | C | 1000 (454) |
| TDE | 72548 | Benzene, 1,1'-(2,2-dichloroethylidene)bis[4-chloro- DDD 4,4' DDD | 1 | 1,2,4 | U060 | X | 1 (0.454) |
| 1,2,4,5-Tetrachlorobenzene | 95943 | Benzene, 1,2,4,5-tetrachloro- | 1* | 4 | U207 | D | 5000 (2270) |
| 2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD) | 1746016 | | 1* | 2 | | X | 1 (0.454) |
| 1,1,1,2-Tetrachloroethane | 630206 | Ethane, 1,1,1,2-tetrachloro- | 1* | 4 | U208 | B | 100 (45.4) |
| 1,1,2,2-Tetrachloroethane | 79345 | Ethane, 1,1,2,2-tetrachloro- | 1* | 2,4 | U209 | B | 100 (45.4) |

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| Tetrachloroethene | 127184 | Ethene, tetrachloro- Perchloroethylene Tetrachloroethylene | 1* | 2,4 | U210 | B | 100 (45.4) |
| Tetrachloroethylene | 127184 | Ethene, tetrachloro- Perchloroethylene Tetrachloroethene | 1* | 2,4 | U210 | B | 100 (45.4) |
| 2,3,4,6-Tetrachlorophenol | 58902 | Phenol, 2,3,4,6-tetrachloro- | 1* | 4 | U212 | A | 10 (4.54) |
| Tetraethyl lead | 78002 | Plumbane, tetraethyl- | 100 | 1,4 | P110 | A | 10 (4.54) |
| Tetraethyl pyrophosphate | 107493 | Diphosphoric acid, tetraethyl ester | 100 | 1,4 | P111 | A | 10 (4.54) |
| Tetraethyldithiopyrophosphate | 3689245 | Thiodiphosphoric acid, tetraethyl ester | 1* | 4 | P109 | B | 100 (45.4) |
| Tetrahydrofuran | 109999 | Furan, tetrahydro- | 1* | 4 | U213 | C | 1000 (454) |
| Tetranitromethane | 509148 | Methane, tetranitro- | 1* | 4 | P112 | A | 10 (4.54) |
| Tetraphosphoric acid, hexaethyl ester | 757584 | Hexaethyl tetraphosphoate | 1* | 4 | P062 | B | 100 (45.4) |
| Thallic oxide | 1314325 | Thallium oxide TI2O3 | 1* | 4 | P113 | B | 100 (45.4) |
| Thallium†† | 7440280 | | 1* | 2 | | C | 1000 (454) |
| Thallium and compounds | N/A | | 1* | 2 | | | ** |
| Thallium (I) acetate | 563688 | Acetic acid, thallium (1+) salt | 1* | 4 | U214 | B | 100 (45.4) |
| Thallium (I) carbonate | 6533739 | Carbonic acid, dithallium (1+) salt | 1* | 4 | U215 | B | 100 (45.4) |
| Thallium (I) chloride | 7791120 | Thallium chlorice TICI | 1* | 4 | U216 | B | 100 (45.4) |
| Thallium chloride TICI | 7791120 | Thallium (I) chloride | 1* | 4 | U216 | B | 100 (45.4) |
| Thallium (I) nitrate | 10102451 | Nitric acid, thallium (1+) salt | 1* | 4 | U217 | B | 100 (45.4) |
| Thallium oxide TI2O3 | 1314325 | Thallic oxide | 1* | 4 | P113 | B | 100 (45.4) |
| Thallium selenite | 12039520 | Selenious acid, dithallium (1+) salt | 1* | 4 | P114 | C | 1000 (454) |
| Thallium (I) sulfate | 7446186 | Sulfuric acid, dithallium (1+) salt | 1000 | 1,4 | P115 | B | 100 (45.4) |
| | 10031591 | | 1000 | 1,4 | P115 | B | 100 (45.4) |
| Thioacetamide | 62555 | Ethanethioamide | 1* | 4 | U218 | A | 10 (4.54) |
| Thiodiphosphoric acid, tetraethyl ester | 3689245 | Tetraethyldithiopyrophosphate | 1* | 4 | P109 | B | 100 (45.4) |
| Thiofanox | 39196184 | 2-Butanone, 3,3-dimethyl-1-(methylthio)-, O[(methylamino) carbonyl] oxime | 1* | 4 | P045 | B | 100 (45.4) |
| Thioimidodicarbonic diamide [(H2N)C(S)] 2NH | 541537 | Dithiobiuret | 1* | 4 | P049 | B | 100 (45.4) |
| Thiomethanol | 74931 | Methanethiol Methylmercaptan | 100 | 1,4 | U153 | B | 100 (45.4) |

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| | | | RQ | Code† | RCRA Waste # | Cate-gory | Pounds (Kg) |
| Thioperoxydicarbonic diamide [(H ₂ N)C(S)] ₂ S ₂ , tetramethyl- | 137268 | Thiram | 1* | 4 | U244 | A | 10 (4.54) |
| Thiophenol | 108985 | Benzenethiol | 1* | 4 | P014 | B | 100 (45.4) |
| Thiosemicarbazide | 79196 | Hydrazinecarbothioamide | 1* | 4 | P116 | B | 100 (45.4) |
| Thiourea | 62566 | | 1* | 4 | U219 | A | 10 (4.54) |
| Thiourea, (2-chlorophenyl)- | 5344821 | 1-(o-Chlorophenyl)thiourea | 1* | 4 | P026 | B | 100 (45.4) |
| Thiourea, 1-naphthalenyl- | 86884 | alpha-Naphthylthiourea | 1* | 4 | P072 | B | 100 (45.4) |
| Thiourea, phenyl- | 103855 | Phenylthiourea | 1* | 4 | P093 | B | 100 (45.4) |
| Thiram | 137268 | Thioperoxydicarbonic diamide [(H ₂ N)C(S)] ₂ S ₂ , tetramethyl- | 1* | 4 | U244 | A | 10 (4.54) |
| Toluene | 108883 | Benzene, methyl- | 1000 | 1,2,4 | U220 | C | 1000 (454) |
| Toluenediamine | 95807 | Benzenediamine, ar-methyl- | 1* | 4 | U221 | A | 10 (4.54) |
| | 496720 | | 1* | 4 | U221 | A | 10 (4.54) |
| | 823405 | | 1* | 4 | U221 | A | 10 (4.54) |
| | 25376458 | | 1* | 4 | U221 | A | 10 (4.54) |
| Toluene diisocyanate | 584849 | Benzene, 1,3-diisocyanatomethyl- | 1* | 4 | U223 | B | 100 (45.4) |
| | 91087 | | 1* | 4 | U223 | B | 100 (45.4) |
| | 26471625 | | 1* | 4 | U223 | B | 100 (45.4) |
| o-Toluidine | 95534 | Benzenamine, 2-methyl- | 1* | 4 | U328 | B | 100 (45.4) |
| p-Toluidine | 106490 | Benzenamine, 4-methyl- | 1* | 4 | U353 | B | 100 (45.4) |
| o-Toluidine hydrochloride | 636215 | Benzenamine, 2-methyl-, hydrochloride | 1* | 4 | U222 | B | 100 (45.4) |
| Toxaphene | 8001352 | Camphene, octachloro- | 1* | 1,2,4 | P123 | X | 1 (0.454) |
| 2,4,5-TP acid | 93721 | Propionic acid 2-(2,4,5-trichlorophenoxy)- Silvex (2,4,5-TP) | 100 | 1,4 | U233 | B | 100 (45.4) |
| 2,4,5-TP esters | 32534955 | | 100 | 1 | | B | 100 (45.4) |
| 1H-1,2,4-Triazol-3-amine | 61825 | Amitrole | 1* | 4 | U011 | A | 10 (4.54) |
| Trichlorfon | 52686 | | 1000 | 1 | | B | 100 (45.4) |
| 1,2,4-Trichlorobenzene | 120821 | | 1* | 2 | | B | 100 (45.4) |
| 1,1,1-Trichloroethane | 71556 | Ethane, 1,1,1-trichloro-Methyl chloroform | 1* | 2,4 | U226 | C | 1000 (454) |
| 1,1,2-Trichloroethane | 79005 | Ethane, 1,1,2-trichloro- | 1* | 2,4 | U227 | B | 100 (45.4) |
| Trichloroethene | 79016 | Ethene, trichloro-Trichloroethylene | 1000 | 1,2,4 | U228 | B | 100 (45.4) |

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| Trichloroethylene | 79016 | Ethene, trichloro-Trichloroethene | 1000 | 1,2,4 | U228 | B | 100 (45.4) |
| Trichloromethanesulfonyl chloride | 594423 | Methanesulfonyl chloride, trichloro- | 1* | 4 | P118 | B | 100 (45.4) |
| Trichloromonofluoromethane | 75694 | Methane, trichlorofluoro- | 1* | 4 | U121 | D | 5000 (2270) |
| Trichlorophenol | 25167822 | | 10 | 1 | | A | 10 (4.54) |
| 2,3,4-Trichlorophenol | 15950660 | | 10 | 1 | | A | 10 (4.54) |
| 2,3,5-Trichlorophenol | 933788 | | 10 | 1 | | A | 10 (4.54) |
| 2,3,6-Trichlorophenol | 933755 | | 10 | 1 | | A | 10 (4.54) |
| 2,4,5-Trichlorophenol | 95954 | Phenol, 2,4,5-trichloro- | 10* | 1,4 | U230 | A | 10 (4.54) |
| 2,4,6-Trichlorophenol | 88062 | Phenol, 2,4,6-trichloro- | 10* | 1,2,4 | U231 | A | 10 (4.54) |
| 3,4,5-Trichlorophenol | 609198 | | | | | | |
| 2,4,5-Trichlorophenol | 95954 | Phenol, 2,4,5-trichloro- | 10* | 1,4 | U230 | A | 10 (4.54) |
| 2,4,6-Trichlorophenol | 88062 | Phenol, 2,4,6-trichloro- | 10 | 1,2,4 | U231 | A | 10 (4.54) |
| Triethanolamine dodecylbenzenesulfonate | 27323417 | | 1000 | 1 | | C | 1000 (454) |
| Triethylamine | 121448 | | 5000 | 1 | | D | 5000 (2270) |
| Trimethylamine | 75503 | | 1000 | 1 | | B | 100 (45.4) |
| 1,3,5-Trinitrobenzene | 99354 | Benzene, 1,3,5-trinitro- | 1* | 4 | U234 | A | 10 (4.54) |
| 1,3,5-Trioxane, 2,4,6-trimethyl- | 123637 | Paraldehyde | 1* | 4 | U182 | C | 1000 (454) |
| Tris(2,3-dibromopropyl) phosphate | 126727 | 1-Propanol, 2,3-dibromo-, phosphate [(3:1)] | 1* | 4 | U235 | A | 10 (4.54) |
| Trypan blue | 72571 | 2,7-Naphthalenedisulfonic acid, 3,3'-3,3'-dimethyl-(1,1'-biphenyl)-4,4'-diyl)-bis(azo)]bis(5-amino-4-hydroxy)-tetrasodium salt | 1* | 4 | U236 | A | 10 (4.54) |
| Unlisted Hazardous Wastes Characteristic of Corrosivity | N/A | | 1* | 4 | D002 | B | 100 (45.4) |
| Unlisted Hazardous Wastes Characteristics: Characteristic of Toxicity: | N/A | | 1* | 4 | | | |
| Arsenic (D004) | N/A | | *1 | 4 | D004 | X | 1 (0.454) |
| Barium (D005) | N/A | | *1 | 4 | D005 | C | 1000 (454) |
| Benzene (D018) | N/A | | 1000 | 1,2,3,4 | D018 | A | 10 (4.54) |
| Cadmium (D006) | N/A | | *1 | 4 | D006 | A | 10 (4.54) |
| Carbon tetrachloride (D019) | N/A | | 5000 | 1,2,4 | D019 | A | 10 (4.54) |

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| | | | RQ | Code† | RCRA Waste # | Cate-gory | Pounds (Kg) |
| Chlordane (D020) | N/A | | 1 | 1,2,4 | D020 | X | 1 (0.454) |
| Chlorobenzene (D021) | N/A | | 100 | 1,2,4 | D021 | B | 100 (45.4) |
| Chloroform (D022) | N/A | | 5000 | 1,2,4 | D022 | A | 10 (4.54) |
| Chromium (D007) | N/A | | *1 | 4 | D007 | A | 10 (4.54) |
| o-Cresol (D023) | N/A | | 1000 | 1,4 | D023 | C | 1000 (454) |
| m-Cresol (D024) | N/A | | 1000 | 1,4 | D024 | C | 1000 (454) |
| p-Cresol (D025) | N/A | | 1000 | 1,4 | D025 | C | 1000 (454) |
| Cresol (D026) | N/A | | 1000 | 1,4 | D026 | C | 1000 (454) |
| 2,4-D (D016) | N/A | | 100 | 1,4 | D016 | B | 100 (45.4) |
| 1,4-Dichlorobenzene (D027) | N/A | | 100 | 1,2,4 | D027 | B | 100 (45.4) |
| 1,2-Dichloroethane (D028) | N/A | | 5000 | 1,2,4 | D028 | B | 100 (45.4) |
| 1,1-Dichloroethylene (D029) | N/A | | 5000 | 1,2,4 | D029 | B | 100 (45.4) |
| 2,4-Dinitrotoluene (D030) | N/A | | 1000 | 1,2,4 | D030 | A | 10 (4.54) |
| Endrin (D012) | N/A | | 1 | 1,4 | D012 | X | 1 (0.454) |
| Heptachlor (and epoxide) (D031) | N/A | | 1 | 1,2,4 | D031 | X | 1 (0.454) |
| Hexachlorobenzene (D032) | N/A | | *1 | 2,4 | D032 | A | 10 (4.54) |
| Hexachlorobutadiene (D033) | N/A | | *1 | 2,4 | D033 | X | 1 (0.454) |
| Hexachloroethane (D034) | N/A | | *1 | 2,4 | D034 | B | 100 (45.4) |
| Lead (D008) | N/A | | *1 | 4 | D008 | | (#) |
| Lindane (D013) | N/A | | 1 | 1,4 | D013 | X | 1 (0.454) |
| Mercury (D009) | N/A | | *1 | 4 | D009 | X | 1 (0.454) |
| Methoxychlor (D014) | N/A | | 1 | 1,4 | D014 | X | 1 (0.454) |
| Methyl ethyl ketone (D035) | N/A | | *1 | 4 | D035 | D | 5000 (2270) |
| Nitrobenzene (D036) | N/A | | 1000 | 1,2,4 | D036 | C | 1000 (454) |
| Pentachlorophenol (D037) | N/A | | 10 | 1,2,4 | D037 | A | 10 (4.54) |
| Pyridine (D038) | N/A | | *1 | 4 | D038 | C | 1000 (454) |
| Selenium (D010) | N/A | | *1 | 4 | D010 | A | 10 (4.54) |
| Silver (D011) | N/A | | *1 | 4 | D011 | X | 1 (0.454) |
| Tetrachloroethylene (D039) | N/A | | *1 | 2,4 | D039 | B | 100 (45.4) |
| Toxaphene (D015) | N/A | | 1 | 1,4 | D015 | X | 1 (0.454) |
| Trichloroethylene (D040) | N/A | | 1000 | 1,2,4 | D040 | B | 100 (45.4) |
| 2,4,5-Trichlorophenol (D041) | N/A | | 10 | 1,4 | D041 | A | 10 (4.54) |

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| | | | RQ | Code† | RCRA Waste # | Category | Pounds (Kg) |
| 2,4,6-Trichlorophenol (D042) | N/A | | 10 | 1,2,4 | D042 | A | 10 (4.54) |
| 2,4,5-TP (D017) | N/A | | 100 | 1,4 | D017 | B | 100 (45.4) |
| Vinyl chloride (D043) | N/A | | *1 | 2,3,4 | D043 | X | 1 (0.454) |
| Unlisted Hazardous Wastes Characteristic of Ignitability | N/A | | 1* | 4 | D001 | B | 100 (45.4) |
| Unlisted Hazardous Wastes Characteristic of Reactivity | N/A | | 1* | 4 | D003 | B | 100 (45.4) |
| Uracil mustard | 66751 | 2,4-(1H,3H)-Pyrimidinedione, 5- [bis(2-chloroethyl)amino]- | 1* | 4 | U237 | A | 10 (4.54) |
| Uranyl acetate | 5411093 | | 5000 | 1 | | B | 100 (45.4) |
| Uranyl nitrate | 10102064 | | 5000 | 1 | | B | 100 (45.4) |
| | 36478769 | | | | | B | |
| Urea, N-ethyl-N-nitroso- | 759739 | N-Nitroso-N-ethylurea | 1* | 4 | U176 | X | 1 (0.454) |
| Urea, N-methyl-N-nitroso | 684935 | N-Nitroso-N-methylurea | 1* | 4 | U177 | X | 1 (0.454) |
| Vanadic acid, ammonium salt | 7803556 | Ammonium vanadate | 1* | 4 | P119 | C | 1000 (454) |
| Vanadium oxide V205 | 1314621 | Vanadium pentoxide | 1000 | 1,4 | P120 | C | 1000 (454) |
| Vanadium pentoxide | 1314621 | Vanadium oxide V205 | 1000 | 1,4 | P120 | C | 1000 (454) |
| Vanadyl sulfate | 27774136 | | 1000 | 1 | | C | 1000 (454) |
| Vinyl chloride | 75014 | Ethene, chloro- | 1* | 2,3,4 | U043 | X | 1 (0.454) |
| Vinyl acetate | 108054 | Vinyl acetate monomer | 1000 | 1 | | D | 5000 (2270) |
| Vinyl acetate monomer | 108054 | Vinyl acetate | 1000 | 1 | | D | 5000 (2270) |
| Vinylamine, N-methyl-N-nitroso- | 4549400 | N-Nitrosomethylvinylamine | 1* | 4 | P084 | A | 10 (4.54) |
| Vinylidene chloride | 75354 | Ethene, 1,1-dichloro- 1,1-Dichloroethylene | 5000 | 1,2,4 | U078 | B | 100 (45.4) |
| Warfarin, & salts, when present at concentrations greater than 0.3% | 81812 | 2H-1-Benzopyran-2-one, 4- hydroxy-3-(3-oxo-1-phenyl-butyl)-, & salts, when present at concentrations greater than 0.3% | 1* | 4 | P001 | B | 100 (45.4) |
| Xylene (mixed) | 1330207 | Benzene, dimethyl | 1000 | 1,4 | U239 | C | 1000 (454) |
| m-Benzene, dimethyl | 108383 | m-Xylene | 1000 | 1,4 | U239 | C | 1000 (454) |
| o-Benzene, dimethyl | 95476 | o-Xylene | 1000 | 1,4 | U239 | C | 1000 (454) |
| p-Benzene, dimethyl | 106423 | p-Xylene | 1000 | 1,4 | U239 | C | 1000 (454) |

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| Xylenol | 1300716 | | 1000 | 1 | | C | 1000 (454) |
| Yohimban-16-carboxylic acid, 11,17-dimethoxy-18-[(3,4,5-trimethoxybenzoyl)oxy]-, methyl ester (3beta,16beta,17alpha,18beta,20alpha)- | 50555 | Reserpine | 1* | 4 | U200 | D | 5000 (2270) |
| Zinc†† | 7440666 | | 1* | 2 | | C | 1000 (454) |
| ZINC AND COMPOUNDS | N/A | | 1* | 2 | | | ** |
| Zinc acetate | 557346 | | 1000 | 1 | | C | 1000 (454) |
| Zinc ammonium chloride | 52628258 | | 5000 | 1 | | C | 1000 (454) |
| | 14639975 | | 5000 | 1 | | C | 1000 (454) |
| | 14639986 | | 5000 | 1 | | C | 1000 (454) |
| Zinc borate | 1332076 | | 1000 | 1 | | C | 1000 (454) |
| Zinc bromide | 7699458 | | 5000 | 1 | | C | 1000 (454) |
| Zinc carbonate | 3486359 | | 1000 | 1 | | C | 1000 (454) |
| Zinc chloride | 7646857 | | 5000 | 1 | | C | 1000 (454) |
| Zinc cyanide | 557211 | Zinc cyanide Zn(CN)2 | 10 | 1,4 | P121 | A | 10 (4.54) |
| Zinc cyanide Zn(CN)2 | 557211 | Zinc cyanide | 10 | 1,4 | P121 | A | 10 (4.54) |
| Zinc fluoride | 7783495 | | 1000 | 1 | | C | 1000 (454) |
| Zinc formate | 557415 | | 1000 | 1 | | C | 1000 (454) |
| Zinc hydrosulfite | 7779864 | | 1000 | 1 | | C | 1000 (454) |
| Zinc nitrate | 7779886 | | 5000 | 1 | | C | 1000 (454) |
| Zinc phenolsulfonate | 127822 | | 5000 | 1 | | D | 5000 (2270) |
| Zinc phosphide | 1314847 | Zinc phosphide Zn3P2, when present at concentrations greater than 10% | 1000 | 1,4 | P122 | B | 100 (45.4) |
| Zinc phosphide Zn3P2, when present at concentrations greater than 10% | 1314847 | Zinc phosphide | 1000 | 1,4 | P122 | B | 100 (45.4) |
| Zinc silicofluoride | 16871719 | | 5000 | 1 | | D | 5000 (2270) |
| Zinc sulfate | 7733020 | | 1000 | 1 | | C | 1000 (454) |
| Zirconium nitrate | 13746899 | | 5000 | 1 | | D | 5000 (2270) |
| Zirconium potassium fluoride | 16923958 | | 5000 | 1 | | C | 1000 (454) |
| Zirconium sulfate | 14644612 | | 5000 | 1 | | D | 5000 (2270) |
| Zirconium tetrachloride | 10026116 | | 5000 | 1 | | D | 5000 (2270) |

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| | | | RQ | Code† | RCRA Waste # | Category | Pounds (Kg) |
| F001 | | | 1* | 4 | F001 | A | 10 (4.54) |
| The following spent halogenated solvents used in degreasing; all spent solvent mixtures/blends used in degreasing containing, before use, a total of ten percent or more (by volume) of one or more of the above halogenated solvents or those solvents listed in F002, F004, and F005; and still bottoms from the recovery of these spent solvents and spent solvent mixtures. | | | | | | | |
| (a) Tetrachloroethylene | 127184 | | 1* | 2,4 | U210 | B | 100 (45.4) |
| (b) Trichloroethylene | 79016 | | 1000 | 1,2,4 | U228 | B | 100 (45.4) |
| (c) Methylene chloride | 75092 | | 1* | 2,4 | U080 | C | 1000 (454) |
| (d) 1,1,1-Trichloroethane | 71556 | | 1* | 2,4 | U226 | C | 1000 (454) |
| (e) Carbon tetrachloride | 56235 | | 5000 | 1,2,4 | U211 | A | 10 (4.54) |
| (f) Chlorinated fluorocarbons | N/A | | | | | D | 5000 (2270) |
| F002 | | | 1* | 2,4 | F002 | A | 10 (4.54) |
| The following spent halogenated solvents; all spent solvent mixtures/blends containing, before use, a total of ten percent or more (by volume) of one or more of the above halogenated solvents or those solvents listed in F002, F004, and F005; and still bottoms from the recovery of these spent solvents and spent solvent mixtures. | | | | | | | |
| (a) Tetrachloroethylene | 127184 | | 1* | 4 | U210 | B | 100 (45.4) |
| (b) Methylene chloride | 75092 | | 1* | 2,4 | U080 | C | 1000 (454) |
| (c) Trichloroethylene | 79016 | | 1000 | 1,2,4 | U228 | B | 100 (45.4) |
| (d) 1,1,1-Trichloroethane | 71556 | | 1* | 2,4 | U226 | C | 1000 (454) |
| (e) Chlorobenzene | 108907 | | 100 | 1,2,4 | U037 | B | 100 (45.4) |
| (f) 1,1,2-Trichloro-1,2,2-trifluoroethane | 76131 | | | | | D | 5000 (2270) |
| (g) o-Dichlorobenzene | 95501 | | 100 | 1,2,4 | U070 | B | 100 (45.4) |
| (h) Trichlorofluoromethane | 75694 | | 1* | 4 | U121 | D | 5000 (2270) |
| (i) 1,1,2-Trichloroethane | 79005 | | 1* | 2,4 | U227 | B | 100 (45.4) |
| F003 | | | 1* | 4 | F003 | B | 100 (45.4) |

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| | | | RQ | Code† | RCRA Waste # | Category | Pounds (Kg) |
| The following spent non-halogenated solvents and the still bottoms from the recovery of these solvents: | | | | | | | |
| (a) Xylene | 1330207 | | | | | C | 1000 (454) |
| (b) Acetone | 67641 | | | | | D | 5000 (2270) |
| (c) Ethyl acetate | 141786 | | | | | D | 5000 (2270) |
| (d) Ethylbenzene | 100414 | | | | | C | 1000 (454) |
| (e) Ethyl ether | 60297 | | | | | B | 100 (45.4) |
| (f) Methyl isobutyl ketone | 108101 | | | | | D | 5000 (2270) |
| (g) n-Butyl alcohol | 71363 | | | | | D | 5000 (2270) |
| (h) Cyclohexanone | 108941 | | | | | D | 5000 (2270) |
| (i) Methanol | 67561 | | | | | D | 5000 (2270) |
| F004 | | | 1* | 4 | F004 | C | 1000 (454) |
| The following spent non-halogenated solvents and the still bottoms from the recovery of these solvents: | | | | | | | |
| (a) Cresols/Cresylic acid | 1319773 | | 1000 | 1,4 | U052 | C | 1000 (454) |
| (b) Nitrobenzene | 98953 | | 1000 | 1,2,4 | U169 | C | 1000 (454) |
| F005 | | | 1* | 4 | F005 | B | 100 (45.4) |
| The following spent non-halogenated solvents and the still bottoms from the recovery of these solvents: | | | | | | | |
| (a) Toluene | 108883 | | 1000 | 1,2,4 | U220 | C | 1000 (454) |
| (b) Methyl ethyl ketone | 78933 | | 1* | 4 | U159 | D | 5000 (2270) |
| (c) Carbon disulfide | 75150 | | 5000 | 1,4 | P022 | B | 100 (45.4) |
| (d) Isobutanol | 78831 | | 1* | 4 | U140 | D | 5000 (2270) |
| (e) Pyridine | 110861 | | 1* | 4 | U196 | C | 1000 (454) |
| F006 | | | 1* | 4 | F006 | A | 10 (4.54) |

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| | | | RQ | Code† | RCRA Waste # | Category | Pounds (Kg) |
| Wastewater treatment sludges from electroplating operations except from the following processes: (1) sulfuric acid anodizing of aluminum, (2) tin plating on carbon steel, (3) zinc plating (segregated basis) on carbon steel, (4) aluminum or zinc-aluminum plating on carbon steel, (5) cleaning/stripping associated with tin, zinc and aluminum plating on carbon steel, and (6) chemical etching and milling of aluminum. | | | | | | | |
| F007 | | | 1* | 4 | F007 | A | 10 (4.54) |
| Spent cyanide plating bath solutions from electroplating operations. | | | | | | | |
| F008 | | | 1* | 4 | F008 | A | 10 (4.54) |
| Plating bath residues from the bottom of plating baths from electroplating operations where cyanides are used in the process. | | | | | | | |
| F009 | | | 1* | 4 | F009 | A | 10 (4.54) |
| Spent stripping and cleaning bath solutions from electroplating operations where cyanides are used in the process. | | | | | | | |
| F010 | | | 1* | 4 | F010 | A | 10 (4.54) |
| Quenching bath residues from oil baths from metal heat treating operations where cyanides are used in the process. | | | | | | | |
| F011 | | | 1* | 4 | F011 | A | 10 (4.54) |
| Spent cyanide solution from salt bath pot cleaning from metal heat treating operations. | | | | | | | |
| F012 | | | 1* | 4 | F012 | A | 10 (4.54) |
| Quenching wastewater treatment sludges from metal heat treating operations where cyanides are used in the process. | | | | | | | |
| F019 | | | 1 | 4 | F019 | A | 10 (4.54) |

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| | | | RQ | Code† | RCRA Waste # | Category | Pounds (Kg) |
| Wastewater treatment sludges from the chemical conversion coating of aluminum except from zirconium phosphating in aluminum can washing when such phosphating is an exclusive conversion coating process. | | | | | | | |
| F020 | | | 1* | 4 | F020 | X | 1 (0.454) |
| Wastes (except wastewater and spent carbon from hydrogen chloride purification) from the production or manufacturing use (as a reactant, chemical intermediate, or component in a formulating process) of tri- or tetrachlorophenol, or of intermediates used to produce their pesticide derivatives. (This listing does not include wastes from the production of hexachlorophene from highly purified 2,4,5-trichlorophenol.) | | | | | | | |
| F021 | | | 1* | 4 | F021 | X | 1 (0.454) |
| Wastes (except wastewater and spent carbon from hydrogen chloride purification) from the production or manufacturing use (as a reactant, chemical intermediate, or component in a formulating process) of pentachlorophenol, or of intermediates used to produce its derivatives. | | | | | | | |
| F022 | | | 1* | 4 | F022 | X | 1 (0.454) |
| Wastes (except wastewater and spent carbon from hydrogen chloride purification) from the manufacturing use (as a reactant, chemical intermediate, or component in a formulating process) of tetra-, penta-, or hexachlorobenzenes under alkaline conditions. | | | | | | | |
| F023 | | | 1* | 4 | F023 | X | 1 (0.454) |

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| | | | RQ | Code† | RCRA Waste # | Cate-gory | Pounds (Kg) |
| Wastes (except wastewater and spent carbon from hydrogen chloride purification) from the production of materials on equipment previously used for the production or manufacturing use (as a reactant, chemical intermediate, or component in a formulating process) of tri- and tetrachlorophenols. (This listing does not include wastes from equipment used only for the production or use of hexachlorophene from highly purified 2,4,5-tri-chlorophenol.) | | | | | | | |
| F024 | | | 1* | 4 | F024 | X | 1 (0.454) |
| Wastes, including but not limited to distillation residues, heavy ends, tars, and reactor cleanout wastes, from the production of chlorinated aliphatic hydrocarbons, having carbon content from one to five, utilizing free radical catalyzed processes. (This listing does not include light ends, spent filters and filter aids, spent dessicants(sic), wastewater, wastewater treatment sludges, spent catalysts, and wastes listed in Section 261.32.) | | | | | | | |
| F025 | | | 1* | 4 | F025 | X | ##1 (0.454) |
| Condensed light ends, spent filters and filter aids, and spent dessicant wastes from the production of certain chlorinated aliphatic hydrocarbons, by free radical catalyzed processes. These chlorinated aliphatic hydrocarbons are those having carbon chain lengths ranging from one to and including five, with varying amounts and positions of chlorine substitution. | | | | | | | |

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| | | | RQ | Code † | RCRA Waste # | Cate-gory | Pounds (Kg) |
| F026 | | | 1* | 4 | F026 | X | 1 (0.454) |
| Wastes (except wastewater and spent carbon from hydrogen chloride purification) from the production of materials on equipment previously used for the manufacturing use (as a reactant, chemical intermediate, or component in a formulating process) of tetra-, penta-, or hexachlorobenzene under alkaline conditions. | | | | | | | |
| F027 | | | 1* | 4 | F027 | X | 1 (0.454) |
| Discarded unused formulations containing tri-, tetra-, or pentachlorophenol or discarded unused formulations containing compounds derived from these chlorophenols. (This listing does not include formulations containing hexachlorophene synthesized from prepurified 2,4,5-tri-chlorophenol as the sole component.) | | | | | | | |
| F028 | | | 1* | 4 | F028 | X | 1 (0.454) |
| Residues resulting from the incineration or thermal treatment of soil contaminated with EPA Hazardous Waste Nos. F020, F021, F022, F023, F026, and F027. | | | | | | | |
| F032 | | | 1* | 4 | F032 | X | 1 (0.454) |
| Wastewaters, process residuals, preservative drippage, and spent formulations from wood preserving processes generated at plants that currently use or have previously used chlorophenolic formulations (except wastes from processes that have had the F032 waste code deleted in accordance with §261.35 and do not resume or initiate use of chlorophenolic formulations). This listing does not include K001 bottom sediment sludge from the treatment of wastewater from wood preserving processes that use creosote and/or pentachlorophenol. | | | | | | | |
| F034 | | | 1* | 4 | F034 | X | 1 (0.454) |

| Hazardous Substance | CASRN | Regulatory Synonyms | Statutory | | | Final RQ | |
|---|-------|---------------------|-----------|-------|--------------|-----------|-------------|
| | | | RQ | Code† | RCRA Waste # | Cate-gory | Pounds (Kg) |
| Wastewaters, process residuals, preservative drippage, and spent formulations from wood preserving processes generated at plants that use creosote formulations. This listing does not include K001 bottom sediment sludge from the treatment of wastewater from wood preserving processes that use creosote and/or pentachlorophenol. | | | | | | | |
| F035 | | | 1* | 4 | F035 | X | 1 (0.454) |
| Wastewaters, process residuals, preservative drippage, and spent formulations from wood preserving processes generated at plants that use inorganic preservatives containing arsenic or chromium. This listing does not include K001 bottom sediment sludge from the treatment of wastewater from wood preserving processes that use creosote and/or pentachlorophenol. | | | | | | | |
| F037 | | | 1* | 4 | F037 | X | 1 (0.454) |

| Hazardous Substance | CASRN | Regulatory Synonyms | Statutory | | | Final RQ | |
|---|-------|---------------------|-----------|-------|--------------|----------|-------------|
| | | | RQ | Code† | RCRA Waste # | Category | Pounds (Kg) |
| Petroleum refinery primary oil/water/solids separation sludge-- Any sludge generated from the gravitational separation of oil/water/solids during the storage or treatment of process wastewaters and oily cooling wastewaters from petroleum refineries. Such sludges include, but are not limited to, those generated in: oil/water/solids separators; tanks and impoundments; ditches and other conveyances; sumps; and stormwater units receiving dry weather flow. Sludge generated in stormwater units that do not receive dry weather flow, sludges generated from non-contact once-through cooling waters segregated for treatment from other process or oily cooling waters, sludges generated in aggressive biological treatment units as defined in §261.31(b)(2) (including sludges generated in one or more additional units after wastewaters have been treated in aggressive biological treatment units) and K051 wastes are not included in this listing. | | | | | | | |
| F038 | | | 1* | 4 | F038 | X | 1 (0.454) |

| Hazardous Substance | CASRN | Regulatory Synonyms | Statutory | | | Final RQ | |
|--|-------|---------------------|-----------|-------|--------------|----------|-------------|
| | | | RQ | Code† | RCRA Waste # | Category | Pounds (Kg) |
| Petroleum refinery secondary (emulsified) oil/water/solids separation sludge--Any sludge and/or float generated from the physical and/or chemical separation of oil/water/solids in process wastewaters and oily cooling wastewaters from petroleum refineries. Such wastes include, but are not limited to, all sludges and floats generated in: induced air flotation (IAF) units, tanks and impoundments, and all sludges generated in DAF units. Sludges generated in stormwater units that do not receive dry weather flow, sludges generated from once-through non-contact cooling waters segregated for treatment from other process or oil cooling wastes, sludges and floats generated in aggressive biological treatment units as defined in 5261.31(b)(2) (including sludges and floats generated in one or more additional units after wastewaters have been treated in aggressive biological treatment units) and F037, K048, and K051 wastes are not included in this listing. | | | | | | | |
| K001 | | | 1* | 4 | K001 | X | 1 (0.454) |
| Bottom sediment sludge from the treatment of wastewaters from wood preserving processes that use creosote and/or pentachlorophenol. | | | | | | | |
| K002 | | | 1* | 4 | K002 | | # |
| Wastewater treatment sludge from the production of chrome yellow and orange pigments. | | | | | | | |
| K003 | | | 1* | 4 | K003 | | # |
| Wastewater treatment sludge from the production of molybdate orange pigments. | | | | | | | |
| K004 | | | 1* | 4 | K004 | A | 10 (4.54) |
| Wastewater treatment sludge from the production of zinc yellow pigments. | | | | | | | |
| K005 | | | 1* | 4 | K005 | | # |

| Hazardous Substance | CASRN | Regulatory Synonyms | Statutory | | | Final RQ | |
|--|-------|---------------------|-----------|-------|--------------|-----------|-------------|
| | | | RQ | Code† | RCRA Waste # | Cate-gory | Pounds (Kg) |
| Wastewater treatment sludge from the production of chrome green pigments. | | | | | | | |
| K006 | | | 1* | 4 | K006 | A | 10 (4.54) |
| Wastewater treatment sludge from the production of chrome oxide green pigments (anhydrous and hydrated). | | | | | | | |
| K007 | | | 1* | 4 | K007 | A | 10 (4.54) |
| Wastewater treatment sludge from the production of iron blue pigments. | | | | | | | |
| K008 | | | 1* | 4 | K008 | A | 10 (4.54) |
| Oven residue from the production of chrome oxide green pigments. | | | | | | | |
| K009 | | | 1* | 4 | K009 | A | 10 (4.54) |
| Distillation bottoms from the production of acetaldehyde from ethylene. | | | | | | | |
| K010 | | | 1* | 4 | K010 | A | 10 (4.54) |
| Distillation side cuts from the production of acetaldehyde from ethylene. | | | | | | | |
| K011 | | | 1* | 4 | K011 | A | 10 (4.54) |
| Bottom stream from the wastewater stripper in the production of acrylonitrile. | | | | | | | |
| K013 | | | 1* | 4 | K013 | A | 10 (4.54) |
| Bottom stream from the acetonitrile column in the production of acrylonitrile. | | | | | | | |
| K014 | | | 1* | 4 | K014 | D | 5000 (2270) |
| Bottoms from the acetonitrile purification column in the production of acrylonitrile. | | | | | | | |
| K015 | | | 1* | 4 | K015 | A | 10 (4.54) |
| Still bottoms from the distillation of benzyl chloride. | | | | | | | |
| K016 | | | 1* | 4 | K016 | X | 1 (0.454) |

| Hazardous Substance | CASRN | Regulatory Synonyms | Statutory | | | Final RQ | |
|--|-------|---------------------|-----------|-------|--------------|----------|-------------|
| | | | RQ | Code† | RCRA Waste # | Category | Pounds (Kg) |
| Heavy ends or distillation residues from the production of carbon tetrachloride. | | | | | | | |
| K017 | | | 1* | 4 | K017 | A | 10 (4.54) |
| Heavy ends (still bottoms) from the purification column in the production of epi-chlorohydrin. | | | | | | | |
| K018 | | | 1* | 4 | K018 | X | 1 (0.454) |
| Heavy ends from the fractionation column in ethyl chloride production. | | | | | | | |
| K019 | | | 1* | 4 | K019 | X | 1 (0.454) |
| Heavy ends from the distillation of ethylene dichloride in ethylene dichloride production. | | | | | | | |
| K020 | | | 1* | 4 | K020 | X | 1 (0.454) |
| Heavy ends from the distillation of vinyl chloride in vinyl chloride monomer production. | | | | | | | |
| K021 | | | 1* | 4 | K021 | A | 10 (4.54) |
| Aqueous spent antimony catalyst waste from fluoromethanes production. | | | | | | | |
| K022 | | | 1* | 4 | K022 | X | 1 (0.454) |
| Distillation bottom tars from the production of phenol/acetone from cumene. | | | | | | | |
| K023 | | | 1* | 4 | K023 | D | 5000 (2270) |
| Distillation light ends from the production of phthalic anhydride from naphthalene. | | | | | | | |
| K024 | | | 1* | 4 | K024 | D | 5000 (2270) |
| Distillation bottoms from the production of phthalic anhydride from naphthalene. | | | | | | | |
| K025 | | | 1* | 4 | K025 | A | 10 (4.54) |
| Distillation bottoms from the production of nitrobenzene by the nitration of benzene. | | | | | | | |
| K026 | | | 1* | 4 | K026 | C | 1000 (454) |

| Hazardous Substance | CASRN | Regulatory Synonyms | Statutory | | | Final RQ | |
|---|-------|---------------------|-----------|--------|--------------|-----------|-------------|
| | | | RQ | Code † | RCRA Waste # | Cate-gory | Pounds (Kg) |
| Stripping still tails from the production of methyl ethyl pyridines. | | | | | | | |
| K027 | | | 1* | 4 | K027 | A | 10 (4.54) |
| Centrifuge and distillation residues from toluene diisocyanate production. | | | | | | | |
| K028 | | | 1* | 4 | K028 | X | 1 (0.454) |
| Spent catalyst from the hydrochlorinator reactor in the production of 1,1,1-trichloroethane. | | | | | | | |
| K029 | | | 1* | 4 | K029 | X | 1 (0.454) |
| Waste from the product steam stripper in the production of 1,1,1-trichloroethane. | | | | | | | |
| K030 | | | 1* | 4 | K030 | X | 1 (0.454) |
| Column bottoms or heavy ends from the combined production of trichloroethylene and perchloroethylene. | | | | | | | |
| K031 | | | 1* | 4 | K031 | X | 1 (0.454) |
| By-product salts generated in the production of MSMA and cacodylic acid. | | | | | | | |
| K032 | | | 1* | 4 | K032 | A | 10 (4.54) |
| Wastewater treatment sludge from the production of chlordane. | | | | | | | |
| K033 | | | 1* | 4 | K033 | A | 10 (4.54) |
| Wastewater and scrub water from the chlorination of cyclopentadiene in the production of chlordane. | | | | | | | |
| K034 | | | 1* | 4 | K034 | A | 10 (4.54) |
| Filter solids from the filtration of hexachlorocyclo-pentadiene in the production of chlordane. | | | | | | | |
| K035 | | | 1* | 4 | K035 | X | 1 (0.454) |
| Wastewater treatment sludges generated in the production of creosote. | | | | | | | |
| K036 | | | 1* | 4 | K036 | X | 1 (0.454) |

| Hazardous Substance | CASRN | Regulatory Synonyms | Statutory | | | Final RQ | |
|--|-------|---------------------|-----------|--------|--------------|----------|-------------|
| | | | RQ | Code † | RCRA Waste # | Category | Pounds (Kg) |
| Still bottoms from toluene reclamation distillation in the production of disulfoton. | | | | | | | |
| K037 | | | 1* | 4 | K037 | X | 1 (0.454) |
| Wastewater treatment sludges from the production of disulfoton. | | | | | | | |
| K038 | | | 1* | 4 | K038 | A | 10 (4.54) |
| Wastewater from the washing and stripping of phorate production. | | | | | | | |
| K039 | | | 1* | 4 | K039 | A | 10 (4.54) |
| Filter cake from the filtration of diethylphosphorodithioic acid in the production of phorate. | | | | | | | |
| K040 | | | 1* | 4 | K040 | A | 10 (4.54) |
| Wastewater treatment sludge from the production of phorate. | | | | | | | |
| K041 | | | 1* | 4 | K041 | X | 1 (0.454) |
| Wastewater treatment sludge from the production of toxaphene. | | | | | | | |
| K042 | | | 1* | 4 | K042 | A | 10 (4.54) |
| Heavy ends or distillation residues from the distillation of tetrachlorobenzene in the production of 2,4,5-T. | | | | | | | |
| K043 | | | 1* | 4 | K043 | A | 10 (4.54) |
| 2,6-Dichlorophenol waste from the production of 2,4-D. | | | | | | | |
| K044 | | | 1* | 4 | K044 | A | 10 (4.54) |
| Wastewater treatment sludges from the manufacturing and processing of explosives. | | | | | | | |
| K045 | | | 1* | 4 | K045 | A | 10 (4.54) |
| Spent carbon from the treatment of wastewater containing explosives. | | | | | | | |
| K046 | | | 1* | 4 | K046 | B | 100 (45.4) |
| Wastewater treatment sludges from the manufacturing, formulation and loading of lead-based initiating compounds. | | | | | | | |

| Hazardous Substance | CASRN | Regulatory Synonyms | Statutory | | | Final RQ | |
|---|-------|---------------------|-----------|-------|--------------|-----------|-------------|
| | | | RQ | Code† | RCRA Waste # | Cate-gory | Pounds (Kg) |
| K047 | | | 1* | 4 | K047 | A | 10 (4,54) |
| Pink/red water from TNT operations. | | | | | | | |
| K048 | | | 1* | 4 | K048 | | # |
| Dissolved air flotation (DAF) float from the petroleum refining industry. | | | | | | | |
| K049 | | | 1* | 4 | K049 | | # |
| Slop oil emulsion solids from the petroleum refining industry. | | | | | | | |
| K050 | | | 1* | 4 | K050 | A | 10 (4,54) |
| Heat exchanger bundle cleaning sludge from the petroleum refining industry. | | | | | | | |
| K051 | | | 1* | 4 | K051 | | # |
| API separator sludge from the petroleum refining industry. | | | | | | | |
| K052 | | | 1* | 4 | K052 | A | 10 (4,54) |
| Tank bottoms (leaded) from the petroleum refining industry. | | | | | | | |
| K060 | | | 1* | 4 | K060 | X | 1 (0,454) |
| Ammonia still lime sludge coking operations. | | | | | | | |
| K061 | | | 1* | 4 | K061 | | # |
| Emission control dust/sludge from the primary production of steel in electric furnances. | | | | | | | |
| K062 | | | 1* | 4 | K062 | | # |
| Spent pickle liquor generated by steel finishing operations of facilities within the iron and steel industry (SIC Codes 331 and 332). | | | | | | | |
| K064 | | | 1* | 4 | K064 | | ## |
| Acid plant blowdown slurry/sludge resulting from thickening of blowdown slurry from primary copper production. | | | | | | | |
| K065 | | | 1* | 4 | K065 | | ## |

| Hazardous Substance | CASRN | Regulatory Synonyms | Statutory | | | Final RO | |
|--|-------|---------------------|-----------|-------|--------------|----------|-------------|
| | | | RO | Code† | RCRA Waste # | Category | Pounds (Kg) |
| Surface impoundment solids contained in and dredged from surface impoundments at primary lead smelting facilities. | | | | | | | |
| K066 | | | 1* | 4 | K066 | | ## |
| Sludge from treatment of process wastewater and/or acid plant blowdown from primary zinc production. | | | | | | | |
| K069 | | | 1* | 4 | K069 | | # |
| Emission control dust/sludge from secondary lead smelting. | | | | | | | |
| K071 | | | 1* | 4 | K071 | X | 1 (0.454) |
| Brine purification muds from the mercury cell process in chlorine production, where separately prepurified brine is not used. | | | | | | | |
| K073 | | | 1* | 4 | K073 | A | 10 (4.54) |
| Chlorinated hydrocarbon waste from the purification step of the diaphragm cell process using graphite anodes in chlorine production. | | | | | | | |
| K083 | | | 1* | 4 | K083 | B | 100 (45.4) |
| Distillate bottoms from aniline extraction. | | | | | | | |
| K084 | | | 1* | 4 | K084 | X | 1 (0.454) |
| Wastewater treatment sludges generated during the production of veterinary pharmaceuticals from arsenic or organo-arsenic compounds. | | | | | | | |
| K085 | | | 1* | 4 | K085 | A | 10 (4.54) |
| Distillation or fractionation column bottoms from the production of chlorobenzenes. | | | | | | | |
| K086 | | | 1* | 4 | K086 | | # |

| Hazardous Substance | CASRN | Regulatory Synonyms | Statutory | | | Final RQ | |
|---|-------|---------------------|-----------|-------|--------------|----------|-------------|
| | | | RQ | Code† | RCRA Waste # | Category | Pounds (Kg) |
| Solvent washes and sludges, caustic washes and sludges, or water washes and sludges from cleaning tubs and equipment used in the formulation of ink from pigments, driers, soaps, and stabilizers containing chromium and lead. | | | | | | | |
| K087 | | | 1* | 4 | K087 | B | 100 (45.4) |
| Decanter tank tar sludge from coking operations. | | | | | | | |
| K088 | | | 1* | 4 | K088 | | |
| Spent potliners from primary aluminum reduction. | | | | | | | |
| K090 | | | 1* | 4 | K090 | | |
| Emission control dust or sludge from ferrochromiumsilicon production. | | | | | | | |
| K091 | | | 1 | 4 | K091 | | |
| Emission control dust or sludge from ferrochromium production. | | | | | | | |
| K093 | | | 1* | 4 | K093 | D | 5000 (2270) |
| Distillation light ends from the production of phthalic anhydride from ortho-xylene. | | | | | | | |
| K094 | | | 1* | 4 | K094 | D | 5000 (2270) |
| Distillation bottoms from the production of phthalic anhydride from ortho-xylene. | | | | | | | |
| K095 | | | 1* | 4 | K095 | B | 100 (45.4) |
| Distillation bottoms from the production of 1,1,1-trichloroethane. | | | | | | | |
| K096 | | | 1* | 4 | K096 | B | 100 (45.4) |
| Heavy ends from the heavy ends column from the production of 1,1,1-trichloroethane. | | | | | | | |
| K097 | | | 1* | 4 | K097 | X | 1 (0.454) |
| Vacuum stripper discharge from the chlordane chlorinator in the production of chlordane. | | | | | | | |
| K098 | | | 1* | 4 | K098 | X | 1 (0.454) |

| Hazardous Substance | CASRN | Regulatory Synonyms | Statutory | | | Final RQ | |
|--|-------|---------------------|-----------|-------|--------------|----------|-------------|
| | | | RQ | Code† | RCRA Waste # | Category | Pounds (Kg) |
| Untreated process wastewater from the production of toxaphene. | | | | | | | |
| K099 | | | 1* | 4 | K099 | A | 10 (4.54) |
| Untreated wastewater from the production of 2,4-D. | | | | | | | |
| K100 | | | 1* | 4 | K100 | | # |
| Waste leaching solution from acid leaching of emission control dust/skudge from secondary lead smelting. | | | | | | | |
| K101 | | | 1* | 4 | K101 | X | 1 (0.454) |
| Distillation tar residues from the distillation of aniline-based compounds in the production of veterinary pharmaceuticals from arsenic or organo-arsenic compounds. | | | | | | | |
| K102 | | | 1* | 4 | K102 | X | 1 (0.454) |
| Residue from the use of activated carbon for decolorization in the production of veterinary pharmaceuticals from arsenic or organo-arsenic compounds. | | | | | | | |
| K103 | | | 1* | 4 | K103 | B | 100 (45.4) |
| Process residues from aniline extraction from the production of aniline. | | | | | | | |
| K104 | | | 1* | 4 | K104 | A | 10 (4.54) |
| Combined wastewater streams generated from nitrobenzene/aniline production. | | | | | | | |
| K105 | | | 1* | 4 | K105 | A | 10 (4.54) |
| Separated aqueous stream from the reactor product washing step in the production of chlorobenzenes. | | | | | | | |
| K106 | | | 1* | 4 | K106 | X | 1 (0.454) |
| Wastewater treatment sludge from the mercury cell process in chlorine production. | | | | | | | |
| K107 | | | 10 | 4 | K107 | X | 10 (4.54) |

| Hazardous Substance | CASRN | Regulatory Synonyms | Statutory | | | Final RQ | |
|--|-------|---------------------|-----------|-------|--------------|-----------|-------------|
| | | | RQ | Code† | RCRA Waste # | Cate-gory | Pounds (Kg) |
| Column bottoms from product separation from the production of 1,1-dimethylhydrazine (UDMH) from carboxylic acid hydrazines. | | | | | | | |
| K108 | | | 10 | 4 | K108 | X | 10 (4.54) |
| Condensed column overheads from product separation and condensed reactor vent gases from the production of 1,1-dimethylhydrazine (UDMH) from carboxylic acid hydrazides. | | | | | | | |
| K109 | | | 10 | 4 | K109 | X | 10 (4.54) |
| Spent filter cartridges from product purification from the production of 1,1-dimethylhydrazine (UDMH) from carboxylic acid hydrazides. | | | | | | | |
| K110 | | | 10 | 4 | K110 | X | 10 (4.54) |
| Condensed column overheads from intermediate separation from the production of 1,1-dimethylhydrazine (UDMH) from carboxylic acid hydrazides. | | | | | | | |
| K111 | | | 1* | 4 | K111 | A | 10 (4.54) |
| Product washwaters from the production of dinitrotoluene via nitration of toluene. | | | | | | | |
| K112 | | | 1* | 4 | K112 | A | 10 (4.54) |
| Reaction by-product water from the drying column in the production of toluenediamine via hydrogenation of dinitrotoluene. | | | | | | | |
| K113 | | | 1* | 4 | K113 | A | 10 (4.54) |
| Condensed liquid light ends from the purification of toluenediamine in the production of toluenediamine via hydrogenation of dinitrotoluene. | | | | | | | |
| K114 | | | 1* | 4 | K114 | A | 10 (4.54) |
| Vicinals from the purification of toluenediamine in the production of toluenediamine via hydrogenation of dinitrotoluene. | | | | | | | |
| K115 | | | 1* | 4 | K115 | A | 10 (4.54) |

| Hazardous Substance | CASRN | Regulatory Synonyms | Statutory | | | Final RQ | |
|---|-------|---------------------|-----------|-------|--------------|----------|-------------|
| | | | RQ | Code† | RCRA Waste # | Category | Pounds (Kg) |
| Heavy ends from the purification of toluenediamine in the production of toluenediamine via hydrogenation of dinitrotoluene. | | | | | | | |
| K116 | | | 1* | 4 | K116 | A | 10 (4.54) |
| Organic condensate from the solvent recovery column in the production of toluene diisocyanate via phosgenation of toluenediamine. | | | | | | | |
| K117 | | | 1* | 4 | K117 | X | 1 (0.454) |
| Wastewater from the reaction vent gas scrubber in the production of ethylene bromide via bromination of ethane. | | | | | | | |
| K118 | | | 1* | 4 | K118 | X | 1 (0.454) |
| Spent absorbent solids from purification of ethylene dibromide in the production of ethylene dibromide. | | | | | | | |
| K123 | | | 1* | 4 | K123 | A | 10 (4.54) |
| Process wastewater (including supernates, filtrates, and washwaters) from the production of ethylene-bisdithiocarbamic acid and its salts. | | | | | | | |
| K124 | | | 1* | 4 | K124 | A | 10 (4.54) |
| Reactor vent scrubber water from the production of ethylenebisdithiocarbamic acid and its salts. | | | | | | | |
| K125 | | | 1* | 4 | K125 | A | 10 (4.54) |
| Filtration, evaporation, and centrifugation solids from the production of ethylenebisdithiocarbamic acid and its salts. | | | | | | | |
| K126 | | | 1* | 4 | K126 | A | 10 (4.54) |
| Baghouse dust and floor sweepings in milling and packaging operations from the production or formulation of ethylenebisdithiocarbamic acid and its salts. | | | | | | | |
| K131 | | | 100 | 4 | K131 | X | 100 (45.4) |

| Hazardous Substance | CASRN | Regulatory Synonyms | Statutory | | | Final RQ | |
|--|-------|---------------------|-----------|-------|--------------|----------|-------------|
| | | | RQ | Code† | RCRA Waste # | Category | Pounds (Kg) |
| Wastewater from the reactor and spent sulfuric acid from the acid dryer in the production of methyl bromide. | | | | | | | |
| K132 | | | 1000 | 4 | K132 | X | 1000 (454) |
| Spent absorbent and wastewater solids from the production of methyl bromide. | | | | | | | |
| K136 | | | 1* | 4 | K136 | X | 1 (0.454) |
| Still bottoms from the purification of ethylene dibromide in the production of ethylene dibromide via bromination of ethene. | | | | | | | |

†Indicates the statutory source as defined by 1,2,3, and 4 below.

††No reporting of releases of this hazardous substance is required if the diameter of the pieces of the solid metal released is equal to or exceeds 100 micrometers (0.004 inches).

†††The RQ for asbestos is limited to friable forms only.

1--Indicates that the statutory source for designation of this hazardous substance under CERCLA is CWA Section 311(b)(4).

2--Indicates that the statutory source for designation of this hazardous substance under CERCLA is CWA Section 307(a).

3--Indicates that the statutory source for designation of this hazardous substance under CERCLA is CAA Section 112.

4--Indicates that the statutory source for designation of this hazardous substance under CERCLA is RCRA Section 3001.

1*--Indicates that the 1-pound RQ is a CERCLA statutory RQ.

#Indicates that the RQ is subject to change when the assessment of potential carcinogenicity is completed.

##The Agency may adjust the statutory RQ for this hazardous substance in a future rulemaking; until then the statutory RQ applies.

5--The adjusted RQs for radionuclides may be found in Appendix B to this table.

**--Indicates that no RQ is being assigned to the generic or broad class.

APPENDIX I

SECTION 313 WATER PRIORITY CHEMICALS

| SECTION 313 WATER PRIORITY CHEMICALS | |
|--------------------------------------|---|
| CAS Number | Common Name |
| 75-07-0 | Acetaldehyde |
| 75865 | Acetane cynohydrin |
| 107-02-8 | Acrolein |
| 107-13-1 | Acrylonitrile |
| 309-00-2 | Aldrin[1,4:5,8-Dimethanonaphthalene, 1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-(1.alpha.,4.alpha.,4a.beta.,5.alpha.,8.alpha.,8a.beta.)-] |
| 107-05-1 | Allyl Chloride |
| 7429-90-5 | Aluminum (fume or dust) |
| 7664-41-7 | Ammonia |
| 62-53-3 | Aniline |
| 120-12-7 | Anthracene |
| 7440-36-0 | Antimony |
| 7647189 | Antimony pentachloride |
| 28300745 | Antimony potassium tartrate |
| 7789619 | Antimony tribromide |
| 10025919 | Antimony trichloride |
| 7783564 | Antimony trifluoride |
| 1309644 | Antimony trioxide |
| 7440-38-2 | Arsenic |
| 1303328 | Arsenic disulfide |
| 1303282 | Arsenic pentoxide |
| 7784341 | Arsenic trichloride |
| 1327533 | Arsenic trioxide |
| 1303339 | Arsenic trisulfide |
| 1332-21-4 | Asbestos (friable) |
| 542621 | Barium cyanide |
| 71-43-2 | Benzene |
| 92-87-5 | Benzidine |
| 100470 | Benzonitrile |
| 98-88-4 | Benzoyl chloride |

| SECTION 313 WATER PRIORITY CHEMICALS | |
|--------------------------------------|---|
| CAS Number | Common Name |
| 100-44-7 | Benzyl chloride |
| 7440-41-7 | Beryllium |
| 7787475 | Beryllium chloride |
| 7787497 | Beryllium fluoride |
| 7787555 | Beryllium nitrate |
| 111-44-4 | Bis(2-chloroethyl) ether |
| 75-25-2 | Bromoform |
| 74-83-9 | Bromomethane (Methyl bromide) |
| 85-68-7 | Butyl benzyl phthalate |
| 7440-43-9 | Cadmium |
| 543908 | Cadmium acetate |
| 7789426 | Cadmium bromide |
| 10108642 | Cadmium chloride |
| 7778441 | Calcium arsenate |
| 52740166 | Calcium arsenite |
| 13765190 | Calcium chromate |
| 592018 | Calcium cyanide |
| 133-06-2 | Captan [1H-isoindole-1,3(2H)-dione,3a,4,7,7a-tetrahydro-2- [[trichloromethyl]thio]-] |
| 63-25-2 | Carbaryl [1-Naphthalenol, methylcarbamate] |
| 75-15-0 | Carbon disulfide |
| 56-23-5 | Carbon tetrachloride |
| 57-74-9 | Chlordane [4,7-Methanoindan,1,2,4,5,6,7,8,8-octachloro-2,3,3a,4,7,7a- hexahydro-] |
| 7782-50-5 | Chlorine |
| 59-50-7 | Chloro-4-methyl-3-phenol <i>p</i> -Chloro- <i>m</i> -cresol |
| 108-90-7 | Chlorobenzene |
| 75-00-3 | Chloroethane (Ethyl chloride) |
| 67-66-3 | Chloroform |
| 74-87-3 | Chloromethane (Methyl chloride) |
| 95-57-8 | 2-Chlorophenol |

| SECTION 313 WATER PRIORITY CHEMICALS | |
|--------------------------------------|---|
| CAS Number | Common Name |
| 106-48-9 | 4-Chlorophenol |
| 1066304 | Chromic acetate |
| 11115745 | Chromic acid |
| 10101538 | Chromic sulfate |
| 7440-47-3 | Chromium |
| 1308-14-1 | Chromium (Tri) |
| 10049055 | Chromous chloride |
| 7789437 | Cobaltous bromide |
| 544183 | Cobaltous formate |
| 14017415 | Cobaltous sulfamate |
| 7440-50-8 | Copper |
| 108-39-4 | <i>m</i> -Cresol |
| 9548-7 | <i>o</i> -Cresol |
| 106-44-5 | <i>p</i> -Cresol |
| 1319-77-3 | Cresol (mixed isomers) |
| 142712 | Cupric acetate |
| 12002038 | Cupric acetoarsenite |
| 7447394 | Cupric chloride |
| 3251238 | Cupric nitrate |
| 5893663 | Cupric oxalate |
| 7758987 | Cupric sulfate |
| 10380297 | Cupric sulfate, ammoniated |
| 815827 | Cupric tartrate |
| 57-12-5 | Cyanide |
| 506774 | Cyanogen chloride |
| 110-82-7 | Cyclohexane |
| 94-75-7 | 2,4-D [Acetic acid, (2,4-dichlorophenoxy)-] |
| 106-93-4 | 1,2-Dibromoethane (Ethylene dibromide) |
| 84-74-2 | Dibutyl phthalate |
| 25321-22-6 | Dichlorobenzene (mixed isomers) |

| SECTION 313 WATER PRIORITY CHEMICALS | |
|--------------------------------------|---|
| CAS Number | Common Name |
| 95-50-1 | 1,2-Dichlorobenzene |
| 541-73-1 | 1,3-Dichlorobenzene |
| 106-46-7 | 1,4-Dichlorobenzene |
| 91-94-1 | 3,3'-Dichlorobenzidine |
| 75-27-4 | Dichlorobromomethane |
| 107-06-2 | 1,2-Dichloroethane (Ethylene dichloride) |
| 540-59-0 | 1,2-Dichloroethylene |
| 120-83-2 | 2,4-Dichlorophenol |
| 78-87-5 | 1,2-Dichloropropane |
| 542-75-6 | 1,3-Dichloropropylene |
| 62-73-7 | Dichlorvos [Phosphoric acid, 2,2-dichloroethenyl dimethyl ester] |
| 115-32-2 | Dicofol [Benzenemethanol, 4-chloro-.alpha.-(4-chlorophenyl)-.alpha.-(trichloromethyl)-] |
| 177-81-7 | Di-(2-ethylhexyl phthalate (DEHP) |
| 84-66-2 | Diethyl phthalate |
| 105-67-9 | 2,4-Dimethylphenol |
| 131-11-3 | Dimethyl phthalate |
| 534-52-1 | 4,6-Dinitro- <i>o</i> -cresol |
| 51-28-5 | 2,4-Dinitrophenol |
| 121-14-2 | 2,4-Dinitrotoluene |
| 606-20-2 | 2,6-Dinitrotoluene |
| 117-84-0 | <i>n</i> -Dioctyl phthalate |
| 122-66-7 | 1,2-Diphenylhydrazine (Hydrazobenzene) |
| 106-89-8 | Epichlorohydrin |
| 100-41-4 | Ethylbenzene |
| 106934 | Ethylene dibromide |
| 50-00-0 | Formaldehyde |
| 76-44-8 | Heptachlor [1,4,5,6,7,8,8-Heptachloro-3a,4,7,7a-tetrahydro-4,7-methano-1H-indene] |
| 118-74-1 | Hexachlorobenzene |
| 87-68-3 | Hexachloro-1,3-butadiene |

| SECTION 313 WATER PRIORITY CHEMICALS | |
|--------------------------------------|---|
| CAS Number | Common Name |
| 77-47-4 | Hexachlorocyclopentadiene |
| 67-72-1 | Hexachloroethane |
| 7647-01-0 | Hydrochloric acid |
| 74-90-8 | Hydrogen cyanide |
| 7664-39-3 | Hydrogen fluoride |
| 7439-92-1 | Lead |
| 301042 | Lead acetate |
| 7784409 | Lead arsenate |
| 7645252 | " " |
| 10102484 | " " |
| 7758954 | Lead chloride |
| 13814965 | Lead fluoborate |
| 7783462 | Lead fluoride |
| 10101630 | Lead iodide |
| 10099748 | Lead nitrate |
| 7428480 | Lead stearate |
| 1072351 | " " |
| 52652592 | " " |
| 7446142 | Lead sulfate |
| 1314870 | Lead sulfide |
| 592870 | Lead thiocyanate |
| 58-89-9 | Lindane [Cyclohexane, 1,2,3,4,5,6-hexachloro- (1.alpha.,3.beta., 4.alpha.,5.alpha.,6.beta.)-] |
| 14307358 | Lithium chromate |
| 108-31-6 | Maleic anhydride |
| 592041 | Mercuric cyanide |
| 10045940 | Mercuric nitrate |
| 7783359 | Mercuric sulfate |
| 592858 | Mercuric thiocyanate |
| 7782867 | Mercurous nitrate |
| 7439-97-6 | Mercury |

| SECTION 313 WATER PRIORITY CHEMICALS | |
|--------------------------------------|--|
| CAS Number | Common Name |
| 72-43-5 | Methoxychlor [Benzene, 1,1'-(2,2,2-trichloroethylidene)bis[4- methoxy-]] |
| 80-62-6 | Methyl methacrylate |
| 91-20-3 | Naphthalene |
| 7440-02-0 | Nickel |
| 15699180 | Nickel ammonium sulfate |
| 37211055 | Nickel chloride |
| 7718549 | " " |
| 12054487 | Nickel hydroxide |
| 14216752 | Nickel nitrate |
| 7786814 | Nickel sulfate |
| 7697-37-2 | Nitric acid |
| 98-95-3 | Nitrobenzene |
| 88-75-5 | 2-Nitrophenol |
| 100-02-7 | 4-Nitrophenol |
| 62-75-9 | <i>N</i> -Nitrosodimethylamine |
| 86-30-6 | <i>N</i> -Nitrosodiphenylamine |
| 621-64-7 | <i>N</i> -Nitrosodi- <i>n</i> -propylamine |
| 56-38-2 | Parathion [Phosphorothioic acid, O,O-diethyl-O-(4-nitrophenyl) ester] |
| 87-86-5 | Pentachlorophenol (PCP) |
| 108-95-2 | Phenol |
| 75-44-5 | Phosgene |
| 7664-38-2 | Phosphoric acid |
| 7723-14-0 | Phosphorus (yellow or white) |
| 1336-36-3 | Polychlorinated biphenyls (PCBs) |
| 7784410 | Potassium arsenate |
| 10124502 | Potassium arsenite |
| 7778509 | Potassium bichromate |
| 7789006 | Potassium chromate |
| 151508 | Potassium cyanide |
| 75-56-9 | Propylene oxide |

| SECTION 313 WATER PRIORITY CHEMICALS | |
|--------------------------------------|---|
| CAS Number | Common Name |
| 91-22-5 | Quinoline |
| 7782-49-2 | Selenium |
| 7446084 | Selenium oxide |
| 7440-22-4 | Silver |
| 7761888 | Silver nitrate |
| 7631892 | Sodium arsenate |
| 7784465 | Sodium arsenite |
| 10588019 | Sodium bichromate |
| 7775113 | Sodium chromate |
| 143339 | Sodium cyanide |
| 10102188 | Sodium selenite |
| 7782823 | " " |
| 7789062 | Strontium chromate |
| 100-42-5 | Styrene |
| 7664-93-9 | Sulfuric acid |
| 79-34-5 | 1,1,2,2-Tetrachloroethane |
| 127-18-4 | Tetrachloroethylene (Perchloroethylene) |
| 935-95-5 | 2,3,5,6-Tetrachlorophenol |
| 78002 | Tetraethyl lead |
| 7440-28-0 | Thallium |
| 10031591 | Thallium sulfate |
| 108-88-3 | Toluene |
| 8001-35-2 | Toxaphene |
| 52-68-6 | Trichlorfon [Phosphonic acid, (2,2,2-trichloro-1-hydroxyethyl)-dimethylester] |
| 120-82-1 | 1,2,4-Trichlorobenzene |
| 71-55-6 | 1,1,1-Trichloroethane (Methyl chloroform) |
| 79-00-5 | 1,1,2-Trichloroethane |
| 79-01-6 | Trichloroethylene |
| 95-95-4 | 2,4,5-Trichlorophenol |
| 88-06-2 | 2,4,6-Trichlorophenol |

| SECTION 313 WATER PRIORITY CHEMICALS | |
|--------------------------------------|-------------------------|
| CAS Number | Common Name |
| 7440-62-2 | Vanadium (fume or dust) |
| 108-05-4 | Vinyl acetate |
| 75-01-4 | Vinyl chloride |
| 75-35-4 | Vinylidene chloride |
| 108-38-3 | <i>m</i> -Xylene |
| 95-47-6 | <i>o</i> -Xylene |
| 106-42-3 | <i>p</i> -Xylene |
| 1330-20-7 | Xylene (mixed isomers) |
| 7440-66-6 | Zinc (fume or dust) |
| 557346 | Zinc acetate |
| 14639975 | Zinc ammonium chloride |
| 14639986 | " " " |
| 52628258 | " " " |
| 1332076 | Zinc borate |
| 7699458 | Zinc bromide |
| 3486359 | Zinc carbonate |
| 7646857 | Zinc chloride |
| 557211 | Zinc cyanide |
| 7783495 | Zinc fluoride |
| 557415 | Zinc formate |
| 7779864 | Zinc hydrosulfite |
| 7779886 | Zinc nitrate |
| 127822 | Zinc phenolsulfonate |
| 1314847 | Zinc phosphide |
| 16871719 | Zinc silicofluoride |
| 7733020 | Zinc sulfate |

APPENDIX J

TABLE OF MONITORING REQUIREMENTS IN EPA'S GENERAL PERMIT

EPA FINAL GENERAL PERMIT MONITORING REQUIREMENTS¹

| Type of Facility | Type of Storm Water Discharge | Parameters | Monitoring Frequency | Reporting Frequency |
|--|--|--|----------------------|---------------------|
| EPCRA, Section 313 Facilities Subject to Reporting Requirements for Water Priority Chemicals | Storm water discharges that come into contact with any equipment, tank, container, or other vessel or area used for storage of a Section 313 water priority chemical, or located at a truck or rail car loading or unloading area where a Section 313 water priority chemical is handled | Oil and Grease, BOD ₅ , COD, TSS, Total Kjeldahl Nitrogen, Total Phosphorus, pH, acute whole effluent toxicity ² , any Section 313 water priority chemical for which the facility reports | Semi-annual | Annual |
| Primary Metal Industries (SIC 33) | All storm water discharges associated with industrial activity | Oil and Grease, COD, TSS, pH, acute whole effluent toxicity ² , Total Recoverable Lead, Total Recoverable Cadmium, Total Recoverable Copper, Total Recoverable Arsenic, Total Recoverable Chromium, and any pollutant limited in an effluent guideline to which the facility is subject | Semi-annual | Annual |
| Land Disposal Units/ Incinerators/ BIFs | Storm water discharges from active or inactive land disposal units without a stabilized cover that have received any waste from industrial facilities other than construction sites; and storm water discharges from incinerators and BIFs that burn hazardous waste | Total Recoverable Magnesium, Magnesium (dissolved), Total Kjeldahl Nitrogen, COD, TDS, TOC, Oil and Grease, pH, Total Recoverable Arsenic, Total Recoverable Barium, Total Recoverable Cadmium, Total Recoverable Chromium, Total Cyanide, Total Recoverable Lead, Total Mercury, Total Recoverable Selenium, Total Recoverable Silver, acute whole effluent toxicity ² | Semi-annual | Annual |

EPA FINAL GENERAL PERMIT MONITORING REQUIREMENTS¹

| Type of Facility | Type of Storm Water Discharge | Parameters | Monitoring Frequency | Reporting Frequency |
|--|---|--|----------------------|---------------------|
| Wood Treatment Facilities | Storm water discharges from areas that are used for wood treatment, wood surface application or storage of treated or surface protected wood Facilities that use chlorophenolic formulations Facilities that use creosote formulations Facilities that use chromium-arsenic formulations | Oil and Grease, pH, COD, TSS Plus Pentachlorophenol and acute whole effluent toxicity ² Plus acute whole effluent toxicity ² Plus Total Recoverable Arsenic, Total Recoverable Chromium, Total Recoverable Copper | Semi-annual | Annual |
| Industrial Facilities with Coal Piles | Storm water discharges from coal pile runoff | Oil and Grease, pH, TSS, Total Recoverable Copper, Total Recoverable Nickel, Total Recoverable Zinc | Semi-annual | Annual |
| Battery Reclaimers | Storm water discharges from areas for storage of lead acid batteries, reclamation products, or waste products, and areas used for lead acid battery reclamation | Oil and Grease, COD, TSS, pH, Total Recoverable Copper, Total Recoverable Lead | Semi-annual | Annual |
| Airports (with over 50,000 flight operations per year) | Storm water discharges from aircraft or airport deicing areas | Oil and Grease, BOD ₅ , COD, TSS, pH, and the primary ingredient used in the deicing materials | Annual | Retain onsite |
| Coal-fired Steam Electric Facilities | Storm water discharges from coal handling sites (other than runoff from coal piles which is not eligible for coverage under this permit) | Oil and Grease, pH, TSS, Total Recoverable Copper, Total Recoverable Nickel, Total Recoverable Zinc | Annual | Retain onsite |

EPA FINAL GENERAL PERMIT MONITORING REQUIREMENTS¹

| Type of Facility | Type of Storm Water Discharge | Parameters | Monitoring Frequency | Reporting Frequency |
|---|---|---|----------------------|---------------------|
| Animal Handling/ Meat Packing Facilities | Storm water discharges from animal handling areas, manure management areas, production waste management areas exposed to precipitation at meat packing plants, poultry packing plants, facilities that manufacture animal and marine fats and oils | BOD5, Oil and Grease, COD, TSS, Total Kjeldahl Nitrogen (TKN), Total Phosphorus, pH, Fecal Coliform | Annual | Retain onsite |
| Chemical and Allied Product Manufacturers/ Rubber Manufacturers (SIC 28 and 30) | Storm water discharges that come into contact with solid chemical storage piles | Oil and Grease, COD, TSS, pH, any pollutant limited in an effluent guideline to which the facility is subject | Annual | Retain onsite |
| Automobile Junkyards | Storm water discharges exposed to: (a) over 250 auto/truck bodies with drivelines, 250 drivelines, or any combination thereof (b) over 500 auto/truck units (c) over 100 units dismantled per year where automotive fluids are drained or stored | Oil and Grease, COD, TSS, pH, any pollutant limited in an effluent guideline to which the facility is subject | Annual | Retain onsite |
| Lime Manufacturing Facilities | Storm water discharges that have come into contact with lime storage piles | Oil and Grease, COD, TSS, pH, any pollutant limited in an effluent guideline to which the facility is subject | Annual | Retain onsite |
| Oil-fired Steam Electric Power Generating Facilities | Storm water discharges from oil handling sites | Oil and Grease, COD, TSS, pH, any pollutant limited in an effluent guideline to which the facility is subject | Annual | Retain onsite |
| Cement Manufacturing Facilities and Cement Kilns | All storm water discharges associated with industrial activity (except those from material storage piles that are not eligible for coverage under this permit) | Oil and Grease, COD, TSS, pH, any pollutant limited in an effluent guideline to which the facility is subject | Annual | Retain onsite |

| EPA FINAL GENERAL PERMIT MONITORING REQUIREMENTS ¹ | | | | |
|---|--|---|----------------------|---------------------|
| Type of Facility | Type of Storm Water Discharge | Parameters | Monitoring Frequency | Reporting Frequency |
| Ready-mix Concrete Facilities | All storm water discharges associated with industrial activity | Oil and Grease, COD, TSS, pH, any pollutant limited in an effluent guideline to which the facility is subject | Annual | Retain onsite |
| Ship Building and Repairing Facilities | All storm water discharges associated with industrial activity | Oil and Grease, COD, TSS, pH, any pollutant limited in an effluent guideline to which the facility is subject | Annual | Retain onsite |

¹A discharger is not subject to the monitoring requirements provided the discharger makes a certification for a given outfall, on an annual basis, under penalty of law, that material handling equipment or activities, raw materials, intermediate products, final products, waste materials, by-products, industrial machinery or operations, significant materials from past industrial activities, or, in the case of airports, deicing activities, that are located in areas of the facility that are within the drainage area of the outfall are not presently exposed to storm water and will not be exposed to storm water for the certification period.

²A discharger may, in lieu of monitoring for acute whole effluent toxicity, monitor for pollutants identified in Tables II and III of Appendix D of 40 CFR Part 122 that the discharger knows or has reason to believe are present at the facility site. Such determinations are to be based on reasonable best efforts to identify significant quantities of materials or chemical present at the facility.



TOXICOLOGICAL REVIEW

OF

HEXAVALENT CHROMIUM

(CAS No. 18540-29-9)

**In Support of Summary Information on the
Integrated Risk Information System (IRIS)**

August 1998

U.S. Environmental Protection Agency
Washington, DC

DISCLAIMER

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(CAS No. 18540-29-9)**

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FOREWORD

The purpose of this Toxicological Review is to provide scientific support and rationale for the hazard identification and dose-response assessment in IRIS pertaining to chronic exposure to Cr(VI). It is not intended to be a comprehensive treatise on the chemical or toxicological nature of Cr(VI).

In Section 6, EPA has characterized its overall confidence in the quantitative and qualitative aspects of hazard and dose response. Matters considered in this characterization include knowledge gaps, uncertainties, quality of data, and scientific controversies. This characterization is presented in an effort to make apparent the limitations of the assessment and to aid and guide the risk assessor in the ensuing steps of the risk assessment process.

For other general information about this assessment or other questions relating to IRIS, the reader is referred to EPA's Risk Information Hotline at 513-569-7254.

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This document and summary information on IRIS have received peer review both by EPA scientists and by independent scientists external to EPA. Subsequent to external review and incorporation of comments, this assessment has undergone an Agencywide review process whereby the IRIS Program Director has achieved a consensus approval among the Office of Research and Development; Office of Air and Radiation; Office of Prevention, Pesticides, and Toxic Substances; Office of Solid Waste and Emergency Response; Office of Water; Office of Planning and Evaluation; and Regional Offices.

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Summaries of the external peer reviewers' comments and the disposition of their recommendations are in Appendix A.

LIST OF ABBREVIATIONS

| | |
|--------|--|
| BAL | Bronchoalveolar lavage |
| BALF | Bronchoalveolar lavage fluid |
| BCF | Bioconcentration factor |
| BMC | Benchmark concentration |
| BMD | Benchmark dose |
| CASRN | Chemical Abstracts Service Registry Number |
| CS | Composite score |
| ESADDI | Estimated safe and adequate dietary intake |
| IRIS | Integrated Risk Information System |
| LDH | Lactate dehydrogenase |
| LOAEL | Lowest-observed-adverse-effect level |
| LOEL | Lowest-observed-effect level |
| MCH | Mean corpuscular hemoglobin |
| MCV | Mean corpuscular volume |
| MED | Minimum effective dose |
| NOAEL | No-observed-adverse-effect level |
| NOEL | No-observed-effect level |
| PCMR | Proportionate cancer mortality ratio |
| ppm | Parts per million |
| RfC | Inhalation reference concentration |
| RfD | Oral reference dose |
| Rvd | Dose-rating value |
| Rve | Effect-rating value |
| SIR | Standard incidence ratio |
| SMR | Standard mortality ratio |
| TWA | Time-weighted average |

1. INTRODUCTION

This document presents background and justification for the hazard and dose-response assessment summaries in EPA's Integrated Risk Information System (IRIS). IRIS Summaries may include an oral reference dose (RfD), inhalation reference concentration (RfC) and a carcinogenicity assessment.

The RfD and RfC provide quantitative information for noncancer dose-response assessments. The RfD is based on the assumption that thresholds exist for certain toxic effects such as cellular necrosis but may not exist for other toxic effects such as some carcinogenic responses. It is expressed in units of mg/kg-day. In general, the RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. The inhalation RfC is analogous to the oral RfD. The inhalation RfC considers toxic effects for both the respiratory system (portal-of-entry) and for effects peripheral to the respiratory system (extrarespiratory or systemic effects). It is generally expressed in units of mg/m³.

The carcinogenicity assessment provides information on the carcinogenic hazard potential of the substance in question and quantitative estimates of risk from oral exposure and inhalation exposure. The information includes a weight-of-evidence judgment of the likelihood that the agent is a human carcinogen and the conditions under which the carcinogenic effects may be expressed. Quantitative risk estimates are presented in three ways. The *slope factor* is the result of application of a low-dose extrapolation procedure and is presented as the risk per mg/kg-day. The *unit risk* is the quantitative estimate in terms of either risk per µg/L drinking water or risk per µg/m³ air breathed. Another form in which risk is presented is a drinking water or air concentration providing cancer risks of 1 in 10,000; 1 in 100,000; or 1 in 1,000,000.

Development of these hazard identifications and dose-response assessments for hexavalent chromium has followed the general guidelines for risk assessment as set forth by the National Research Council (1983). EPA guidelines that were used in the development of this assessment may include the following: the *Guidelines for Carcinogen Risk Assessment* (U.S. EPA, 1986a), *Guidelines for the Health Risk Assessment of Chemical Mixtures* (U.S. EPA, 1986b), *Guidelines for Mutagenicity Risk Assessment* (U.S. EPA, 1986c), *Guidelines for Developmental Toxicity Risk Assessment* (U.S. EPA, 1991), *Proposed Guidelines for Neurotoxicity Risk Assessment* (U.S. EPA, 1995a), *Proposed Guidelines for Carcinogen Risk Assessment* (U.S. EPA, 1996a), *Guidelines for Reproductive Toxicity Risk Assessment* (U.S. EPA, 1996b), and *Guidelines for Neurotoxicity Risk Assessment* (U.S. EPA, 1998a); *Recommendations for and Documentation of Biological Values for Use in Risk Assessment* (U.S. EPA, 1988); (proposed) *Interim Policy for Particle Size and Limit Concentration Issues in Inhalation Toxicity* (U.S. EPA, 1994a); *Methods for Derivation of Inhalation Reference Concentrations and Application of Inhalation Dosimetry* (U.S. EPA, 1994b); *Peer Review and Peer Involvement at the U.S. Environmental Protection Agency* (U.S. EPA, 1994c); *Use of the Benchmark Dose Approach in Health Risk Assessment* (U.S. EPA, 1995b); *Science Policy Council Handbook: Peer Review* (U.S. EPA, 1998b); and memorandum from EPA Administrator, Carol Browner, dated March 21, 1995, Subject: Guidance on Risk Characterization.

Literature search strategies employed for this compound were based on the CASRN and at least one common name. At a minimum, the following databases were searched: RTECS, HSDB, TSCATS, CCRIS, GENETOX, EMIC, EMICBACK, DART, ETICBACK, TOXLINE, CANCERLINE, MEDLINE AND MEDLINE backfiles. Any pertinent scientific information submitted by the public to the IRIS Submission Desk was also considered in the development of this document.

2. CHEMICAL AND PHYSICAL INFORMATION RELEVANT TO ASSESSMENTS

In the hexavalent state, chromium exists as oxo species such as CrO_3 and CrO_4^{2-} that are strongly oxidizing (Cotton and Wilkinson, 1980). The CAS Registry numbers and the solubilities of a few important hexavalent chromium compounds are given in Table 1.

In solution, hexavalent chromium exists as hydrochromate (HCrO_4^-), chromate (CrO_4^{2-}), and dichromate ($\text{Cr}_2\text{O}_7^{2-}$) ionic species. The proportion of each ion in solution is pH dependent. In basic and neutral pH, the chromate form predominates. As the pH is lowered (6.0 to 6.2), the hydrochromate concentration increases. At very low pH, the dichromate species predominate (U.S. EPA, 1984).

The primary sources of hexavalent chromium in the atmosphere are chromate chemicals used as rust inhibitors in cooling towers and emitted as mists, particulate matter emitted during manufacture and use of metal chromates, and chromic acid mist from the plating industry (ATSDR, 1993). Hexavalent chromium in air eventually reacts with dust particles or other pollutants to form trivalent chromium (NAS, 1974); however, the exact nature of such atmospheric reactions has not been studied extensively. Both hexavalent and trivalent chromium are removed from air by atmospheric fallout and precipitation (Fishbein, 1981). The atmospheric half-life for the physical removal mechanism is dependent on the particle size and particle density. Chromium particles of small aerodynamic diameter ($< 10 \mu\text{m}$) will remain airborne for a long period (U.S. EPA, 1984).

Hexavalent chromium may exist in aquatic media as water-soluble complex anions and may persist in water. Hexavalent chromium is a strong oxidizing agent and may react with organic matter or other reducing agents to form trivalent chromium. The trivalent chromium will eventually be precipitated as $\text{Cr}_2\text{O}_3 \cdot x\text{H}_2\text{O}$. Therefore, in surface water rich in organic content, hexavalent chromium will exhibit a much shorter lifetime (Callahan et al., 1979).

Any hexavalent chromium in soil is expected to be reduced to trivalent chromium by organic matter. The primary processes by which the converted trivalent chromium is lost from soil are aerial transport through aerosol formation and surface water transport through runoff (U.S. EPA, 1984). Very little chromium is leached from soil because it is present as insoluble $\text{Cr}_2\text{O}_3 \cdot x\text{H}_2\text{O}$ (Fishbein, 1981).

The bioconcentration factor (BCF) for hexavalent chromium in fish muscle appears to be < 1.0 (U.S. EPA, 1980), but values of 125 and 192 were obtained for oyster and blue mussel, respectively (U.S. EPA, 1980).

Table 1. CAS numbers and aqueous solubilities of selected hexavalent chromium compounds

| Compound | CAS No. | Water solubility |
|---|----------------|-------------------------|
| Ammonium chromate (NH ₄) ₂ CrO ₄ | 7788-98-9 | 40.5 g/100 mL at 30°C |
| Calcium chromate CaCrO ₄ | 13765-19-0 | 2.23 g/100 mL at 20°C |
| Chromic acid CrO ₃ | 1333-82-0 | 61.7 g/100 mL at 0°C |
| Potassium chromate K ₂ CrO ₄ | 7789-50-6 | 62.9 g/100 mL at 20°C |
| Potassium dichromate K ₂ Cr ₂ O ₇ | 7789-50-9 | 4.9 g/100 mL at 0°C |
| Sodium chromate Na ₂ CrO ₄ | 7775-11-3 | 87.3 g/100 mL at 30°C |
| Sodium dichromate dihydrate | 7789-12-0 | 230 g/100 mL at 0°C |

Sources: Weast, 1980; Hartford, 1979.

3. TOXICOKINETICS RELEVANT TO ASSESSMENTS

3.1. ABSORPTION FACTORS IN HUMANS AND EXPERIMENTAL ANIMALS

3.1.1. Oral

Gastrointestinal absorption of Cr(VI) occurs with greater efficiency than absorption of Cr(III), though absorption of ingested hexavalent chromium is estimated to be less than 5%. Donaldson and Barreras (1966) fed $\text{Na}^{51}\text{CrO}_4$ to rats and humans. Based on mean urinary excretion, ^{51}Cr absorption was estimated to be 2.1% in humans. In rats, approximately 2% of the administered dose was absorbed based on fecal excretion of ^{51}Cr when $\text{Na}^{51}\text{CrO}_4$ was administered intragastrically. Intestinal absorption of hexavalent chromium appears to be significantly affected by contact with gastric juices. When $\text{Na}^{51}\text{CrO}_4$ was introduced to humans intraduodenally (avoiding contact with gastric juices), approximately half of the chromium was absorbed based on fecal excretion. Similar results were observed following intrajejunal administration in rats. Incubation of hexavalent chromium with gastric juices prior to intraduodenal or intrajejunal administration in humans and rats, respectively, virtually eliminated absorption of chromium. Absorption of trivalent chromium ($^{51}\text{CrCl}_3$) was not increased by intraduodenal or intrajejunal administration. The authors demonstrated that hexavalent chromium is reduced to the trivalent form by incubation with gastric juices and concluded that reduction of hexavalent chromium to the trivalent form in the stomach significantly reduces absorption by the oral route of exposure. Gastric juices have peak reductive capacity 2 to 4 hours after a meal and are at a minimum between meals and at night (DeFlora et al., 1987). Anderson et al. (1983) confirmed the low absorption of trivalent chromium in humans following oral administration of 200 μg of CrCl_3 .

MacKenzie et al. (1959) administered $\text{Na}^{51}\text{CrO}_4$ to rats by gavage. Based on urinary excretion, absorption was estimated to be 6% in fasted rats and 3% in nonfasted rats. The rate of absorption was twofold greater than that observed following administration of $^{51}\text{CrCl}_3$ by gavage. Absorption of hexavalent chromium was found to be increased by three- to fivefold following intestinal administration of $\text{Na}^{51}\text{CrO}_4$, consistent with reduction of hexavalent chromium during passage through the stomach. Absorption of hexavalent and trivalent chromium was found to be less than 1.4% in the hamster (Henderson et al., 1979), while Visek (1953) estimated that less than 0.5% of ingested CrCl_3 was absorbed through the gastrointestinal tract of the rat.

3.1.2. Inhalation

A number of factors can influence the absorption of chromium following inhalation, including the size, oxidation state, and solubility of the chromium particles; the activity of alveolar macrophages; and the interaction of chromium with biomolecules following deposition in the lung (ATSDR, 1993). Absorption of inhaled chromium following occupational exposure has been demonstrated by measurement of chromium in the serum, urine, and hair of workers in the chromium industry (Minoia and Cavalleri, 1988; Randall and Gibson, 1987; Tossavainen et al., 1980).

Langard et al. (1978) demonstrated that water-soluble hexavalent chromium, such as chromic acid, is absorbed rapidly following inhalation by rats. However, insoluble hexavalent chromium, such as zinc chromate, is less well absorbed. Animals were exposed to zinc chromate dust at a level of 7.35 mg/m³. After 0, 100, 250, and 350 min of exposure, the concentrations of chromium in the blood (µg/ml) were 0.007, 0.024, 0.22, and 0.31, respectively. In the second part of this study, rats were exposed to the same level for 6 hours on 4 consecutive days. Blood concentrations appeared to peak at the end of the second exposure and then began to decline slowly. Mean blood chromium values measured at the end of each exposure period averaged 0.03, 0.56, 0.46, and 0.34 µg/ml for exposures 1-4, respectively. No significant differences in absorption as reflected by blood chromium levels were noted between the sexes or between day and night exposures.

Suzuki et al. (1984) exposed rats to potassium dichromate (VI) or Cr(III) trichloride by inhalation and determined that while lung clearance of both valence states was dependent on particle size, Cr(VI) was absorbed with threefold greater efficiency than Cr(III).

3.1.3. Metabolism

In vivo reduction of Cr(VI) to Cr(III) has been widely studied, and some characterizations can be made. Ingested hexavalent chromium is efficiently reduced to the trivalent form by the gastric juices (DeFlora et al., 1987). Hexavalent chromium can also be reduced to the trivalent form in the epithelial lining fluid of the lungs by ascorbate and glutathione. The reduction by ascorbate is more rapid than by glutathione, and results in a shorter residence time for chromium in the lungs (Suzuki and Fukuda, 1990).

Once absorbed into the bloodstream, hexavalent chromium readily enters red blood cells through the phosphate and sulfate anion-exchange carrier pathway, though a portion may remain in plasma for an extended period (Wiegand et al., 1985). While Cr(III) compounds are unable to cross the red cell membrane by this pathway (Gray and Sterling, 1950), they may enter red blood cells, but only with very low efficiency (Mertz, 1969; O'Flaherty, 1996). Hexavalent chromium is reduced to the trivalent form in the red blood cell by the action of glutathione (Debetto and Luciani, 1988; Petrilli and De Flora, 1978a). During reduction to the trivalent form, chromium may interact with cellular macromolecules, including DNA (Wiegand et al., 1985), or may be slowly released from the cell (Bishop and Surgenor, 1964).

Visek et al. (1953) reported that an insignificant amount of ⁵¹Cr crossed the placenta of rats in the 24 hours following intravenous injection regardless of the chemical form injected, the valence state, the gestational stage, or the size of the litter. In no instance was the radioactivity measured in the fetuses greater than 0.13% of the dose. Danielsson et al. (1982) reported that sodium dichromate crossed the placenta more readily than Cr(III) trichloride following intravenous injection of mouse dams. Casey and Hembridge (1984) demonstrated that chromium can be transferred to infants through breast milk. The breast milk of 45 lactating women was found to have a chromium content averaging 0.3 µg/L. These concentrations were taken to represent background levels in women whose chromium exposure occurs primarily through the diet.

A physiologically based model for chromium has recently been developed, which incorporates absorption and disposition schemes for Cr(VI) and Cr(III) throughout the body (O'Flaherty, 1996). The model was calibrated on the basis of published oral and intratracheal kinetic studies using soluble Cr(III) and Cr(VI) in the rat, and accounts for most of the major features of chromium kinetics, including reduction of Cr(VI) to Cr(III). The model suggests the following *in vivo* disposition for chromium. Both Cr(III) and Cr(VI) are poorly absorbed from the lung and the gastrointestinal tract. Following inhalation exposure, chromium may be absorbed into the systemic circulation, transferred to the gastrointestinal tract by mucociliary action, or remain in the lung. Cr(VI) is reduced to Cr(III) in all tissues, including the lung and the gastrointestinal tract. Both Cr(III) and Cr(VI) are better absorbed from the gastrointestinal tract in the fasted than in the fed state, and the absorption efficiency of Cr(III) salts is largely dependent on the nutritional status of the animal as well as the nature of the anion making up the Cr(III) salt. The model assumes that reduction of Cr(VI) does not occur in the plasma. Cr(VI) enters cells by the phosphate and sulfate anion-exchange carrier pathway. Cr(III) travels in the bloodstream largely bound to amino acids, other organic acids, and plasma proteins such as globulins. The complexes of Cr(III) that are bound to lower molecular weight ligands are most likely to be able to traverse cell membranes (Mertz, 1969). A significant amount of absorbed chromium is taken up in the bone (Witmer and Harris, 1991; Weber, 1983), Chromium is also concentrated in tissues of the liver, kidney, and spleen. Once in the cell, Cr(VI) may be reduced to Cr(III), which may subsequently interact with cellular macromolecules including DNA (Wiegand et al., 1985), or may be slowly released from the cell (Bishop and Surgenor, 1964). The model suggests that the bioaccessibility of chromium to absorption processes may be the single most important factor determining the toxicity of a specific chromium source (O'Flaherty, 1996).

Given the rapid reduction of Cr(VI) to Cr(III) *in vivo*, it is relevant to consider whether environmental exposures to Cr(VI) or administration of Cr(VI) in controlled animal experiments is essentially identical to environmental exposures to Cr(III) or administration of Cr(III) in controlled experiments. Although considerably more data are available for Cr(VI) than for Cr(III), it appears at present that exposures to Cr(VI) have considerably different outcomes than exposures to Cr(III). The Agency has prepared the toxicological summaries and IRIS files for Cr(VI) and Cr(III) from this perspective.

3.1.4. The Essentiality of Chromium

Cr(III) in its biologically active form (glucose tolerance factor, or GTF, a dinicotinato-chromium[III] glutathione-like complex), facilitates interaction of insulin with its receptor site, influencing glucose, protein, and lipid metabolism. Thus, Cr(III) is essential for animals and human beings. Inorganic chromium compounds do not appear to have insulin-potentiating activity. Chromium deficiency may cause changes in the metabolism of glucose and lipids. In some studies, dietary supplementation with chromium reversed changes in glucose tolerance and serum lipids. The National Research Council has identified an estimated safe and adequate daily dietary intake (ESADDI) for chromium of 50-200 µg/d (NRC, 1989), corresponding to 0.71-2.9 µg/kg/day for a 70-kg adult. FDA has selected a Reference Daily Intake for chromium of 120 µg/d (DHHS, 1995).

4. HAZARD IDENTIFICATION

4.1. STUDIES IN HUMANS

4.1.1. Oral

Cr(VI) is considerably more toxic than Cr(III). A cross-sectional study of 155 villagers reported the effects of environmental contamination of well water adjacent to a chromium alloy plant. Cr(VI) concentrations were reported as 20 mg/L, with an estimated dose rate of 0.57 mg/kg-day (Zhang and Li, 1987). Reported effects at this dose included oral ulcers, diarrhea, abdominal pain, indigestion, vomiting, leukocytosis, and presence of immature neutrophils. Effects data for lower exposure doses were not available.

Other reports of toxic effects in humans are limited to case reports from accidental poisonings. Some Cr(VI) compounds (such as potassium tetrachromate and chromic acid) are potent oxidizing agents, and are thus strong irritants of mucosal tissue. Effects included metabolic acidosis, acute tubular necrosis, kidney failure, and death (Saryan and Reedy, 1988).

4.1.2. Inhalation

Occupational exposure to chromium compounds has been studied in the chromate-production, chrome-plating and chrome pigment, ferrochromium production, gold mining, leather tanning, and chrome alloy production industries.

Workers in the chromate industry are exposed to both trivalent and hexavalent compounds of chromium. Epidemiological studies of chromate production plants in Japan, Great Britain, West Germany, and the United States have revealed a correlation between occupational exposure to chromium and lung cancer, but the specific form of chromium responsible for the induction of cancer was not identified (Machle and Gregorius, 1948; Baejter, 1950a,b; Bidstrup, 1951; Mancuso and Hueper, 1951; Brinton et al., 1952; Bidstrup and Case, 1956; Todd, 1962; Taylor, 1966; Enterline, 1974; Mancuso, 1975; Ohsaki et al., 1978; Sano and Mitohara, 1978; Hayes et al., 1979; Hill and Ferguson, 1979; Alderson et al., 1981; Hagenor et al., 1981; Satoh et al., 1981; Korallus et al., 1982; Frentzel-Beyme, 1983; Langard and Vigander, 1983; Watanabe and Fukuchi, 1984; Davies, 1984; Mancuso, 1997).

Mancuso and Hueper (1951) conducted a proportional mortality study of a cohort of chromate workers (employed for > 1 year from 1931 to 1949 in a Painesville, OH, chromate plant) in order to investigate lung cancer associated with chromate production. Of the 2,931 deaths of males in the county where the plant is located, 34 (1.2%) were due to respiratory cancer. Of the 33 deaths among the chromate workers, however, 6 (18.2%) were due to respiratory cancer. Within the limitations of the study design, this report strongly suggested an increased incidence of respiratory cancer in the chromate-production plant.

In an update of the Mancuso and Hueper (1951) study, Mancuso (1975) followed 332 of the workers employed from 1931-1951 until 1974. By 1974, > 50% of this cohort had died. Of

these men, 63.6%, 62.5%, and 58.3% of the cancer deaths for men employed in 1931-1932, 1933-1934 and 1935-1937, respectively, were due to lung cancer. Lung cancer death rates increased with increases in exposure to total chromium, and significant deposition of chromium was found in the lungs of workers long after the exposure ceased. The age-specific lung cancer rates from and gradient exposures to total chromium from this study are presented in Table 2. Mancuso (1975) reported that these lung cancer deaths were related to insoluble (trivalent), soluble (hexavalent), and total chromium exposure, but the small numbers involved make identification of the specific form of chromium responsible for the lung cancer uncertain.

Mancuso (1997) recently updated this study, following the combined cohort of 332 workers until 1993. Of 283 deaths (85% of the cohort identified), 66 lung cancers were found (23.3% of all deaths and 64.7% of all cancers). Lung cancer rates clearly increased by gradient level of exposure to total chromium. The relationship between gradient level of exposure and lung cancer rates is less clear for trivalent and hexavalent chromium. The rates of lung cancer within the cohort are consistent with those reported in Mancuso (1975) and provide further support for the cancer risk assessment based on those data.

Hayes et al. (1979) conducted a study of 2,101 male workers in a chromium chemicals production plant in Baltimore, MD, to determine whether employment in a modernized facility resulted in a reduction in the risk of lung cancer in comparison with that seen in workers employed in older production facilities. Mortality data for the workers were compared with cause-specific mortality rates for Baltimore city males, and correlations were made between a history of having worked in specific job positions and cancer of the lung. Workers with lung cancer as an underlying or contributory cause of death were individually matched to controls selected from plant workers who died of causes other than cancer. Many of the specific causes of death, including several sites of malignancy, showed results well below the expected number. While the newer facility had been constructed to reduce exposure to carcinogens, workers in the new facility were still found to have an increased risk of lung cancer. Both short-term and long-term workers were found to have excess risk for lung cancer, but the effect was more pronounced in the long-term workers. A dose-response relationship with respect to length of employment was observed, and long-term laborers were found to have a maximum risk (standard mortality ratio [SMR] = 3.9) between 15 and 19 years after the initial exposure. A history of having worked with highly soluble hexavalent chromium compounds in the “wet end” of the production process was particularly associated with an increased risk of lung cancer. Among the workers in the low- exposure group (n = 699), no excess risk was demonstrated. The authors were unable to obtain suitable data to account for cigarette smoking in the study population, and assumed that the smoking habits of workers were similar to those of the in the general population.

Pastides et al. (1994) conducted a retrospective cohort study in the United States’ largest chromate chemicals manufacturing facility in Castle Hayne, NC. This plant was designed to reduce the high level of chromium exposure found at most of the older chromate production facilities. The study utilized more than 5,000 personal breathing zone samples collected over a 15-year period. Occupational, medical, and smoking data from current and former employees were collected using a questionnaire. A healthy-worker effect was observed in the population. There was no increased risk of mortality or cancer among employees who worked only at this

Table 2. Age-specific lung cancer death rates and gradient exposures to total chromium

| | | Mg/m³ - Yrs. total insoluble chromium | | | | | | |
|------------|--------------|---|-----------------|-----------------|-----------------|-----------------|-----------------|----------------------|
| Age | | < 1.00 | 1.0-1.99 | 2.0-3.99 | 4.0-5.99 | 6.0-6.99 | 7.0-7.99 | 8^a |
| 45-54 | Deaths | 1 | 2 | 2 | 4 | 3 | 3 | 0 |
| | Person-years | 886 | 459 | 583 | 348 | 159 | 140 | 262 |
| 55-64 | Deaths | 1 | 3 | 1 | 4 | 2 | 3 | 1 |
| | Person-years | 707 | 356 | 462 | 250 | 113 | 98 | 203 |
| 65-74 | Deaths | 1 | 1 | 2 | 1 | 1 | 0 | 3 |
| | Person-years | 235 | 166 | 182 | 80 | 42 | 41 | 81 |

^aData in the last column are not used in EPA's risk assessment because the range of exposure in this class is not known, and it does not appear reasonable to assume that all three age groups had an identical exposure distribution.

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Source: Mancuso, 1975.

facility, though a subgroup of workers who transferred from older facilities was found to have higher risks of mortality and cancer.

Rosenman and Stanbury (1996) recently reported on a study of lung cancer risk in a population of former workers from four facilities that produced chromium compounds from chromite ore. Workers at these facilities between 1937 and 1971 were found to have proportionate cancer mortality ratios (PCMR) of 1.51 for white men and 1.34 for black men. The PCMRs were found to increase with duration of employment and time since first employment. The authors also reported a PCMR for nasal/sinus cancer of 5.18. The lung cancer risk remained elevated for more than 20 years following the cessation of exposure. While the study was unable to account for smoking habits of the workers, the lack of increase in other smoking-related diseases suggested that the lung cancer was not related to smoking. The authors were unable to distinguish risk from trivalent and hexavalent chromium, and were also unable to examine risk by exposure estimates.

Alexander et al. (1996) reported on a study of lung cancer in chromate-exposed aerospace workers with a minimum of 6 mo exposure to hexavalent chromium. Standard incidence ratios (SIRs) for lung cancer were determined on the basis of the duration of employment in chromate-exposure jobs and cumulative exposure. The authors reported an inverse relationship between lung cancer risk and estimates of cumulative chromate exposure in spray painters. Elevated lung cancer risks were found for subjects who worked as chrome platers or surface processor tank tenders, sanders/maskers, and polishers, but the numbers are too low to establish a clear association between chromate exposure and lung cancer risk in these workers. The authors suggested that the lack of increased lung cancer risk among spray painters may reflect the exposure to chromate in paint mists, which they suggested may render the hexavalent chromium less biologically active.

Studies of workers in chromate pigment production plants have demonstrated an association with increased risk of lung cancer. Hayes et al. (1989) studied workers employed between 1940 and 1969 in a lead and zinc chromate pigment production plant in New Jersey. The SMR for lung cancer was 160, based on comparison with U.S. lung cancer rates for white males. Workers in the high-exposure group were continuously exposed to greater than 2 mg/m³ chromate dust; workers in the moderate-exposure group were occasionally exposed to concentrations between 0.5 and 2 mg/m³; and workers in the low-exposure group were infrequently exposed at concentrations below 0.1 mg/m³. Significant SMRs were also found for lung cancer in nonwhite males and stomach cancer in white males. Air monitoring revealed that exposures were lead chromate.

Davies (1978, 1979) studied three chromate pigment plants in England, two of which produced both zinc and lead chromate, and one which produced only lead chromate. The cohort of exposed workers consisted of employees with ≥ 1 year of service and for whom vital statistics were available as of 1977. Using these guidelines, 396 and 136 subjects were obtained from the plants producing both zinc and lead chromate, and 114 subjects were obtained from the plant that produced only lead chromate. The observed mortality from lung cancer in the different plants was compared to the expected mortality based on national lung cancer mortality rates for all

males in England and Wales. An elevated risk of lung cancer was present only in the plants producing both zinc and lead chromate. The authors suggested that these data indicated that zinc chromate was associated with the etiology of lung cancer, whereas lead chromate was not.

Davies (1984) conducted a follow-up study on workers in the same three chromate pigment production plants. Workroom chromium concentrations and smoking statistics for the workers were not available in any of the factories. Elevated SMRs for lung cancer were observed, particularly for workers employed prior to improvements in industrial hygiene. Workers in the high- and medium-exposure groups in a plant producing lead and zinc chromates had an SMR for lung cancer of 232. Workers in high- and medium-exposure groups in a second lead and zinc chromate production plant had a SMR for lung cancer of 373. The SMR for workers in high and medium groups exposed to lead, zinc, and strontium chromate was 562. In the third plant, only lead chromate pigments were produced, and no excess lung cancer deaths were reported.

Langard and Norseth (1975) reported on three pigment plants in Norway that were in operation between 1948 and 1972 (one of the plants was brought on line in the year the study ended). A total of 133 workers were identified as employees at the three plants during this time period. Of the 133, 24 had been employed > 3 years, and of this cohort, 3 cases of lung cancer were identified through the Cancer Registry of Norway. All of the lung cancer cases had been employed for 5 years or longer. Data from the cancer registry indicated an expected number of lung cancer cases among those employed of 0.079; thus, the observed number of cases was 38 times greater than expected, based on the general population. Exposure levels determined by personal monitoring were reported for the plants for the year 1972, with chromium levels in the two older plants ranging between 0.04 and 1.35 mg/m³ and levels in the new plant between 0.01 and 0.08 mg/m³. Although an increased risk of lung cancer was indicated, two of the individuals with lung cancer were moderate to heavy smokers. Nevertheless, a relative risk of lung cancer of 38 could not be explained by differences in smoking between the study cohort and the Norwegian population. Langard and Vigander (1983) conducted a follow-up study on workers employed for at least 3 years in the same chromate pigment producing factories. Workroom monitoring revealed significantly elevated concentrations of hexavalent chromium (0.01 - 1.35 mg/m³), and an SMR for lung cancer of 4,444 was reported. Workers in this group were exposed over a period of 6-9 years.

Frentzel-Beyme (1983) reported that the observed number of lung cancer deaths exceeded those expected among workers in five chromate pigment plants in the Netherlands and West Germany. In only one factory, however, was this excess statistically significant. The authors did not find a lung cancer mortality dose-response by intensity or duration of exposure. The analysis was limited by the numbers of deaths in each category.

Several studies of the chrome-plating industry have demonstrated a positive relationship between cancer and exposure to chromium compounds (Royle, 1975; Franchini et al., 1983; Sorahan et al., 1987). Royle (1975) studied mortality in the chromium plating industry in England in a retrospective study between 1969 and 1972. Workers in this industry are exposed to hexavalent chromium in the form of chromic acid mist and some sodium dichromate dust.

The study traced 1,238 chrome plating workers employed for > 3 months along with 1,284 manual laborers used as controls. There was little difference in smoking habits between the groups. There was a significant ($p < 0.05$) difference in the death rate for cancer at all sites, 3.15% in chrome platers as compared to 1.63% in controls. Deaths from malignancy of the lung and gastrointestinal tract were each increased, though not significantly.

Franchini et al. (1983) conducted a retrospective cohort study of 178 workers in nine Italian chromeplating plants to determine the mortality of workers employed for at least 1 year between January 1951 and December 1981. The mortality experience of workers was compared to that for the Italian male population of the same age during the follow-up period. Direct exposure measures from the plants were not available, but the exposures were related to airborne chromium concentrations taken from Italian electroplating plants in 1980, after industrial hygiene practices had improved considerably. A significant excess of all malignancies and lung cancer specifically was found for the workers in “hard” chromeplating plants, who were expected to have the greatest chromium exposures. While the small size of the cohort limited the statistical power of the study and confounding factors were not assessed, this study is taken to provide suggestive evidence of a causal relationship between exposure to chromic acid and cancer.

Sorahan et al. (1987) conducted a mortality study of nickel/chromium platers in England who were employed between 1946 and 1983. Exposure in these the plants was to soluble hexavalent chromic acid mist (CrO_3). The cohort in the study included a population of 2,689 workers (1,288 men, 1,401 women). Workers’ exposure to chromium was estimated based on participation in any of eight chromeplating job categories and on cumulative duration of employment in chrome bath jobs. The mortality experience of the cohort was evaluated through comparison with that expected for the general population of England and Wales, as well as through comparison of the estimated chrome exposures of workers who died in a given year with those of matching survivors in the same follow-up year, controlling for sex, year of starting chrome employment, and age starting in chrome employment. Overall, compared with the general population, significant differences were found for all cancers, cancers of the lung and bronchus, cancer of the nose and nasal cavities, cancer of the stomach, and primary cancer of the liver. The results were particularly striking for chrome bath workers, who were likely the most heavily exposed to chromium. Significant positive associations were found between cancers of the lung and bronchus and duration of chrome bath work.

Some studies of the chromeplating industry have reported inconclusive results (Silverstein et al., 1981; Okubo and Tsuchiya, 1979; Takahashi and Okubo, 1990; Itoh et al., 1996). Okubo and Tsuchiya (1979) conducted a cohort study of 889 Tokyo chrome platers, with an unspecified number of controls selected from the same factories. The study included a 6-year follow-up period. The investigation was conducted by a questionnaire sent to the manager of each factory, and vital statistics were ascertained using the records of the Tokyo Health Insurance Society of the Plating Industry. The recovery rate of the questionnaire was 70.5%. Among the 889 male chromium platers, 19 deaths were observed, or about 50% of those expected (healthy-worker effect). In contrast, the authors reported a slightly higher percentage of deaths in the control group. The authors reported negative results for the relationship between chromeplating

and lung cancer; however, the results were not related to well-defined exposure data and the study utilized a very short follow-up period.

Takahashi and Okubo (1990) reported on an epidemiological study of metal platers in 415 small chromeplating plants in Japan. Members of the cohort were all male workers employed as platers for at least 6 mo between April 1970 and September 1976. The follow-up period extended until 1987 and no members of the cohort were lost to follow-up. The members of the cohort were classified into two subgroups based on their work histories: 52% of the cohort had more than 6 mo experience in chrome plating and 48% of the cohort had more than 6 mo plating experience using metals other than chromium. The mean duration of exposure before the follow-up period was 12.3 years. The study lacked direct exposure measures, and smoking histories for the workers were not available. All-cause mortality in the cohort was slightly below the expected number (healthy-worker effect). The study demonstrated that exposure to metal plating is associated with a statistically significant increase in lung cancer, though the elevated SMR was not statistically significant in either of the two plater subgroups. While chromium platers with initial exposure prior to 1960 had a 2.5-fold (though statistically insignificant) excess incidence of lung cancer, there was no increase in numbers of deaths due to lung cancer relative to the length of time exposed to chromeplating. The results of this study are considered equivocal regarding the relationship between chromeplating and lung cancer. Itoh et al. (1996) subsequently reported on a prospective cohort study of the same cohort of 1,193 workers at small Japanese plating facilities. While a trend toward statistical significance for risk of lung cancer was seen in the chromium plating subgroup, the study lacked sufficient statistical power to form a clear conclusion.

Silverstein et al. (1981) found a statistically significant increase ($p < 0.001$) in the lung cancer proportionate mortality ratios for both male and female white employees in a die-casting and electroplating plant. In this plant, workers were exposed to chromium during electroplating, but nickel and copper were also used in electroplating. Other operations of the plant included zinc alloy die-casting, buffing and polishing, and cleaning of zinc and steel parts. No conclusion can be made from this study regarding the association of chromium electroplating and lung cancer mortality, because of the employees' exposure to other potential carcinogens.

A number of epidemiological studies have considered the association between inhalation of Cr(VI) and noncarcinogenic endpoints, including upper respiratory irritation and atrophy, lower respiratory effects, and systemic effects.

Bloomfield and Blum (1928) examined 23 men from 6 chromium plating plants in the United States. Fourteen of these workers typically spent 2-7 hours/day over vats of chromic acid, which generated airborne hexavalent chromium ranging from 0.12 to 5.6 mg/m³. These men experienced nasal tissue damage, including perforated septum (2), ulcerated septum (3), chrome holes (6), nosebleed (9), and inflamed mucosa (9). In general, the nine remaining workers examined, not directly exposed to chromium vapors, had only inflamed mucosae. The authors concluded that chromic acid at concentrations greater than 0.1 mg/m³ is likely to cause nasal tissue injury. However, no concentrations lower than 0.12 mg/m³ were observed, and injury to nasal tissue caused by lower concentrations could not be ruled out.

Machle and Gregorius (1948) reported an incidence of nasal septal perforation of 43.5% in 354 employees who worked in a chromate-producing plant that manufactured sodium chromate and bichromate. At the time of the study, airborne chromate concentrations ranged from 10 to 2,800 $\mu\text{g}/\text{m}^3$. The plant had been in operation for at least 17 years, and some employees probably worked in the plant when reverberatory furnaces, a prominent source of high chromate exposure, were used.

Mancuso and Hueper (1951) reported on physical examinations of a random sample of 97 workers from a chromate-chemical plant. The results indicated that 61 of the 97 workers (63%) had septal perforation. The data suggested to the author that Cr(III) may be partly responsible for the perforations; however, there are insufficient data to make an unequivocal conclusion.

The U.S. Public Health Service conducted a study of workers in seven chromate-producing plants in the early 1950s. Of 897 chromate industry workers in the study, 57% were found to have a nasal septum perforation. Perforated septum was observed even in workers employed less than 6 mo. The study indicated that exposure to chromate results in severe nasal tissue destruction, but exposure levels were not measured; hence, the data are of limited usefulness for risk assessment purposes (Federal Security Agency, 1953).

Vigliani and Zurlo (1955) reported nasal septal perforation in workers exposed to chromic acid and chromates in concentrations of 0.11-0.15 mg/m^3 . The lengths of exposure were not known. Hanslian et al., (1967) reported on otolaryngologic examinations of 77 persons exposed to chromic acid aerosol during chrome plating. Among this group, 19% were observed to have septal perforation and 48% to have nasal mucosal irritation. The workers averaged 6.6 years of exposure to an airborne chromium concentration of 0.4 mg/m^3 . In 14 persons, papillomas of the oral cavity and larynx were found. The diagnosis of papilloma was confirmed by histologic examination. There were no signs of atypical growth or malignant degeneration.

Kleinfeld and Russo (1965) reported some degree of nasal septal ulceration in 7 of 9 workers in a chromeplating plant, with 4 of 7 demonstrating frank perforations. Analyses of air samples showed chromium concentrations of 0.18-1.4 mg/m^3 . Data regarding the length of exposure and exposure concentration for individual workers were not available.

Gomes (1972) examined 303 employees who worked in 81 electroplating operations in Sao Paulo, Brazil. More than two-thirds of the workers had mucous membrane or cutaneous lesions, with many of them having ulcerated or perforated nasal septa. The duration of exposure was not stated, but the author mentioned that the harmful effects were noted in < 1 year. A direct correlation between workers exposed to a given airborne concentration of Cr(VI) and the development of harmful effects could not be made.

Cohen and Kramkowski (1973) and Cohen et al. (1974) examined 37 workers (7 male and 30 female) employed in the nickel-chrome department of an electroplating plant in comparison with 21 workers (15 male and 6 female) in other areas of the plant not significantly exposed to chromic acid. Smoking demographic data were not provided. Environmental air samples were collected from breathing zones of several workers in the exposed and control

groups to determine concentrations of total chrome and Cr(VI). Brief medical histories were confined to the ear, nose, throat, and cutaneous structures. Within 1 year of employment, 12 workers experienced nasal ulceration or perforation. Nasal ulcers and perforations were associated with total chromium concentrations of 1.4 to 49.3 $\mu\text{g}/\text{m}^3$, averaging 7.1 $\mu\text{g}/\text{m}^3$, and Cr(VI) concentrations of 0.09 to 9.1 $\mu\text{g}/\text{m}^3$, averaging 2.9 $\mu\text{g}/\text{m}^3$. Ninety-five percent of the 37 workers studied exhibited pathologic changes in nasal mucosa in a concentration-duration response. More than half of the workers employed less than 1 year had nasal pathology that was more severe than simple redness of the nasal mucosa. Almost all the workers (35 of 37) employed longer than 1 year had nasal tissue damage. The authors noted the lack of good industrial hygiene practices, implicating direct contact, such as touching of the nose with chromium-contaminated hands, as a potentially important route of exposure.

Lucas and Kramkowski (1975) conducted a health hazard evaluation of 11 employees in the “hard” chrome area of an industrial plating facility. The average age of the employees was 39 years and the average duration of employment in the hard chrome area was 7.5 years. Medical examinations were conducted to evaluate the presence of dermatitis, chrome holes, old chrome hole scars, ulcerated nasal septum, infection of the mucosa, nasal redness, perforated nasal septum, reddened throat, conjunctivitis, and wheezing. Environmental air samples were collected from the breathing zone on all workers in the hard chrome area to determine the concentrations of hexavalent chromium. Cr(VI) concentrations ranged from 1 to 20 $\mu\text{g}/\text{m}^3$, averaging 4 $\mu\text{g}/\text{m}^3$. However, the authors attributed the nasal pathology primarily to direct contact. Clinical observations included injection of the nasal mucosa in five workers, ulcerated nasal septum in two workers, atrophic scarring indicative of the presence of past ulceration in two workers, and complete perforation of the nasal septum in four workers. Poor hygiene practices including touching the nose with the hand were noted at the plant and represented a confounding factor in the etiology of the nasal lesions.

Markel and Lucas (1973) conducted a health hazard evaluation of 32 workers at a “cold dip” chromeplating plant who were employed in the chrome department or who regularly spent a portion of their workday in that area. Twenty of the employees worked in the chrome area of the plant for more than 5 years. A total of 16 personal and 7 general air samples were taken to determine the concentrations of Cr(VI). Maximum airborne Cr(VI) concentration was 3 $\mu\text{g}/\text{m}^3$. No workers were found to have ulcerated nasal mucosa or perforated nasal septa. Half of the 32 employees had varying degrees of mucosal irritation. The authors did not consider this to be significant, because the survey was carried out at the peak of the 1972-1973 influenza epidemic.

Lindberg and Hedenstierna (1983) compared lung function, the condition of the nasal septum, and subjective symptoms related to respiratory health (data obtained by questionnaire) in unexposed controls (119) and workers (43) exposed to chromic acid in chromeplating operations. Exposed workers were divided into low- (< 2) and high- (> 2 $\mu\text{g Cr[VI]}/\text{m}^3$) exposure groups based on the exposures they were likely to have experienced in the workplace. Complaints of diffuse nasal symptoms (“constantly running nose,” “stuffy nose,” or “a lot to blow out”) were registered by 4/19 workers in the low-exposure group and half of the 24 workers in the high exposure group. The authors reported reddening of the nasal mucosa at 1 to 2 $\mu\text{g}/\text{m}^3$ and nasal irritation (chronic and nasal septal ulceration and perforation) in two-thirds of the subjects at

concentrations from 2 to 20 $\mu\text{g}/\text{m}^3$. All workers with nasal ulceration had been exposed to chrome acid mist, which contained Cr(VI) at 20 $\mu\text{g}/\text{m}^3$, or greater than 20 $\mu\text{g}/\text{m}^3$ near the baths. Changes in pulmonary function measurements, as determined by changes in vital capacity and forced expiratory volume at 1 sec (FEV_1), were seen in workers who experienced Cr(VI) exposures greater than 2 $\mu\text{g}/\text{m}^3$. Examination of the nasal septum revealed that damage was significantly greater in exposed workers than in unexposed controls and appeared to be somewhat more severe in the high-exposure group than the low-exposure group. There was a tendency for lung function parameters to return to normal over a 2-day weekend.

In the United States, 97 workers in chromate-producing plants had a higher incidence of severely red throats and pneumonia, but did not show any increase in the incidence of other respiratory diseases when compared with control groups. Although bilateral hilar enlargement was observed, there was no evidence of excessive pulmonary fibrosis in these workers (Federal Security Agency, 1953). The various lung changes described in these workers may represent a nonspecific reaction to irritating material or a specific reaction to chromium compounds. Many of the conditions mentioned occur widely in the general population (NAS, 1974).

Lindberg and Vesterberg (1983a) studied urinary excretion of proteins in 24 currently employed chrome platers and 27 former chrome platers. Results were compared with those for a group of 37 referents. Exposures for current workers were determined using personal samplers and were found to range from 2 to 20 $\mu\text{g}/\text{m}^3$, with an average level of 6 $\mu\text{g}/\text{m}^3$. Exposure levels of former platers were thought to be higher than those for the current workers. The duration of exposure ranged from < 1 to 26 years. Cr(VI) exposure was found to result in renal effects in a dose-dependent fashion (based on elevated excretion of β -2-microglobulin as an indicator of nephrotoxicity) in current workers exposed to 4 to 20 $\mu\text{g}/\text{m}^3$ Cr(VI) over 8-hour shifts. The effect may be reversible because former chromeplaters did not have an elevated concentration of either β -2-microglobulin or albumin in their urine. Most of the currently exposed workers were also observed to have irritation symptoms of the airways, including ulcerated nasal septum and complete perforations. Severe objective and subjective levels for the airway effects occurred at NOAEL levels for renal toxicity.

In another study, Saner et al. (1984) did not find increased urinary β -2-microglobulin levels in tannery workers in comparison to referent control workers. However, comparison of urinary chromium concentrations of the tannery workers in this study versus the chromeplaters in the Lindberg and Vesterberg (1983a,b) study suggests that the latter had distinctly higher chromium exposures.

Various other disease states have been attributed to chromium, but in most cases, the etiologic relation to chromium is doubtful because of the presence of other chemicals (NAS, 1974). These studies, reviewed by EPA (1984) and ATSDR (1993), will not be reviewed here.

4.2. SUBCHRONIC, CHRONIC STUDIES AND CANCER BIOASSAYS IN ANIMALS

4.2.1. Chronic Oral Studies

Only one chronic study pertaining to the oral toxicity of hexavalent chromium was located in the available literature. Anwar et al. (1961) exposed dogs orally to potassium chromate in drinking water for 4 years. Treatment levels were 0, 0.45, 2.25, 4.5, 6.75, and 11.2 ppm potassium chromate; there were two dogs/group. No effects were observed with regard to gross and microscopic analysis of all major organs, urinalysis, and weights of spleen, liver, and kidney.

4.2.2. Subchronic Oral Studies

The National Toxicology Program recently conducted a three-part reproductive toxicity study to investigate oral ingestion of hexavalent chromium in experimental animals (NTP, 1996a,b, 1997). Rats and mice were exposed to 0 - 400 ppm potassium dichromate daily in the diet for 9 weeks. Animals were examined for body weights; feed and water consumption; organ weights; microscopic evaluation of the liver, kidney, and ovaries; hematology; histology of the testis and epididymus for Sertoli nuclei and preleptotene spermatocyte counts in Stage X or XI tubules; and chromatin analysis. No treatment-related hematology findings were reported except for slight decreases in mean corpuscular volume (MCV) and mean corpuscular hemoglobin (MCH) values in the male and female treatment groups receiving 400 ppm potassium dichromate (24 mg/kg-day). The findings were characterized by the authors as suggestive of a potential bone marrow/erythroid response. The authors considered the 100 ppm (6 mg/kg-day) dose group to be representative of the NOAEL for the study. The studies are described in greater detail in the reproductive/developmental section of this document.

MacKenzie et al. (1958) exposed groups of eight male and eight female Sprague-Dawley rats to 0-11 ppm (0-11 mg/L) hexavalent chromium (as K_2CrO_4) for 1 year in drinking water. The control group (10/sex) received distilled water. A second experiment involved three groups of 12 male and 9 female rats. One group was given 25 ppm (25 mg/L) chromium (as K_2CrO_4), a second group received 25 ppm chromium in the form of chromic chloride, and the controls again received distilled water. The results of the MacKenzie et al. study are presented in Table 3. No significant adverse effects were seen on appearance, weight gain, or food consumption, and there were no pathologic changes in the blood or other tissues in any treatment group. The rats receiving 25 ppm of chromium (as K_2CrO_4) showed an approximate 20% reduction in water consumption. This dose corresponds to 2.5 mg Cr(VI)/kg/day based on actual body weight and water consumption data. Blood was examined monthly, and tissues (livers, kidneys, and femurs) were examined at 6 mo and 1 year. Spleens were also examined at 1 year. The 25 ppm groups (and corresponding controls) were examined similarly, except that no animals were killed at 6 mo. An abrupt rise in tissue chromium concentrations was noted in rats treated with greater than 5 ppm. The authors stated that "apparently, tissues can accumulate considerable quantities of chromium before pathological changes result." In the 25 ppm treatment groups, tissue concentrations of chromium were approximately nine times higher for those treated with hexavalent chromium than for the animals exposed to trivalent chromium.

Table 3. Subchronic oral toxicity of hexavalent chromium in rats

| Number of animals | Dose and compound | Period of exposure | Endpoints monitored and effect |
|--|--|---------------------------|--|
| 9 females, 12 males at 25 ppm 10 males, 19 females at 9 ppm 8 males, 8 females at other treatment levels | 0, 0.45, 2.2, 4.5, 7.7, 11, 25 ppm as potassium dichromate in drinking water | 1 year | No effect based on body weight, gross external condition, histopathological analysis, and blood chemistry. |

Source: MacKenzie et al., 1958.

Gross and Heller (1946) reported that 0.125% K_2CrO_4 in the feed of rats was tolerated without observable effects. A dose of 0.25% in the diet resulted in “subnormal condition,” including rough coat and “subnormal” young born to treated animals. Doses of 0.5% and 1% in feed resulted in diarrhea, rough dirty coats, and sterility. $ZnCrO_4$ administered in the feed at levels of 0.125%, 0.25%, 0.5%, and 1.0% resulted in subnormal appearance, rough and dirty coats, and sterility at all dose levels. Group sizes, duration of treatment, and criteria for determining sterility were not reported.

4.2.3. Chronic Inhalation Studies

Two studies have provided suggestive evidence of carcinogenicity in mice and rats following inhalation of hexavalent chromium (Nettesheim et al., 1971; Glaser et al., 1986). Nettesheim et al. (1971) exposed C57B1 mice to 13 mg calcium chromate/ m^3 (4.33 mg $Cr(VI)/m^3$ as calcium chromate dust), 5 hours/day, 5 days/week for life. Chromium exposure resulted in a cessation of body weight gain at 6 mo followed by a decrease in body weight thereafter. Bronchial epithelial effects ranged from marked hyperplasia and atrophy to necrosis, suggesting that the maximum tolerated dose may have been exceeded in this study. Inflammatory infiltration into the subepithelium including proliferation of bronchial epithelial cells was noted. Distension of terminal bronchioli and alveoli resembling emphysema was associated with alveolar proteinosis. A 2.8% increase in the number of lung tumors was reported with respect to controls. However, statistical analysis was not performed, and the significance of these results is unclear. In a review of this study, IARC (1990) concluded that a significant excess of treatment-related tumors was not observed. Nettesheim identified 4.33 mg of calcium chromate dust/ m^3 as a LOAEL for the occurrence of epithelial necrosis, marked hyperplasia and atrophy of the pulmonary bronchi, emphysema-like changes, and atrophy of the spleen and liver. The single dose used in this study raises the question whether 4.33 mg $Cr(VI)/m^3$ actually represents a LOAEL.

Glaser et al. (1986) exposed male Wistar rats (20/group) to aerosols of sodium chromate at measured concentrations of 0.025, 0.05, and 0.1 mg Cr(VI)/m³, 22 hr/day, 7 days/week for 18 mo. An additional group was exposed to a pyrolyzed Cr(VI)/Cr(III) (3:2) oxide mixture at 0.063 Cr(VI)/m³. The animals were held under conventional conditions for 12 mo following the exposure. Body weights and mortality were similar among all exposure groups and controls. Primary lung tumors (1 adenocarcinoma and 2 adenomas) and 1 squamous cell carcinoma of the pharynx were evident in the high-chromate exposure group. It is not clear whether the adenocarcinoma and adenomas occurred in the same animal or in different animals. One primary lung adenoma was observed in the oxide-exposed group. Primary lung tumors were not observed in the controls or low-chromate exposure groups. Dose-dependent retention of chromium was seen in the chromate- and oxide-exposed groups relative to the controls. At the conclusion of the study, lung chromium retention was 10-fold greater in the oxide-exposed group than in the high-chromate-exposed group. Significantly increased lung weights were determined for the oxide-exposed group and greater liver weights in the high-exposure group of the chromate. Pigment-loaded macrophages were found in a dose-dependent manner in rats exposed to chromate and to the oxide. Oxide-exposed rats developed focal thickened septa, partially combined with interstitial fibrosis and accumulation of eosinophilic substance in the alveolar lumens. Oxide-exposed groups also demonstrated elevated white- and red-blood cell counts, elevated serum cholesterol, and decreased total serum immunoglobulin levels. The results of this study may provide evidence of a weak carcinogenic potency of aerosols of both sodium dichromate and Cr(VI/III) oxide (Glaser et al., 1986; Glaser et al., 1988).

Steinhoff et al. (1983) investigated the carcinogenicity of soluble sodium dichromate and calcium chromate in Sprague-Dawley rats via intratracheal administration and reported positive carcinogenic effects. The study consisted of 10 treatment groups, one negative control group, and two positive control groups. Each test group contained 40 male and 40 female rats (10 weeks old at the outset). The design of the dose levels selected was such as to assess the impacts of the chemicals delivered in single high doses or in the same dose distributed over a 5-day period. The duration of the study was 2 years and 8 months. Doses ranged from 0.5 to 1.25 mg/kg. Rats administered sodium dichromate or calcium chromate one or five times per week had no significant reduction in survival periods as compared to controls, except in the case of females treated with calcium chromate 5×0.25 mg/kg/week. An increased incidence of lung tumors as compared to controls was observed in the treated group in which sodium dichromate was administered in a single dose of 1.25 mg. No lung tumors were observed in the other sodium dichromate treatment groups. In rats administered calcium chromate, statistically significant increases in lung tumors were found in groups treated with a single dose of 1.25 mg/kg as well as in the group treated with 5×0.25 mg/kg/week distributed over a period of 5 days.

There is some evidence that hexavalent chromium may be carcinogenic following intrapleural implantation of calcium chromate (Hueper and Payne, 1962) or intrabronchial implantation of strontium chromate, calcium chromate, or zinc chromate (Levy and Martin, 1983). These tumors, however, were observed only at the site of implantation. Steffee and Baetjer (1965) observed statistically significant increases in lung tumors following intratracheal

instillation of 0.01 to 0.03 mg zinc chromate in strain A mice. The instillations were performed at 2-week intervals and the animals were observed until death.

In contrast, intratracheal and intrapleural implantation studies of other chromium compounds have not demonstrated increases in tumor incidences. Mixed hexavalent and trivalent chromium-containing dust was not carcinogenic in strain A Swiss and C57BL mice and mixed-breed rats following intratracheal implantation (Baetjer et al., 1959). Steffee and Baetjer (1965) did not observe increases in lung adenomas following instillation of chromium dust, zinc chromate, and lead chromate into the tracheas of guinea pigs and rabbits. Hueper and Payne (1962) reported similar negative results after instillation of strontium chromate or calcium chromate suspended in gelatin; however, the experimental detail in the report was insufficient for adequate evaluation. Hueper and Payne (Hueper, 1955, 1958; Payne, 1960; Hueper and Payne, 1962) described a series of studies in rats treated by intrapleural injection of a number of hexavalent or trivalent compounds. Hueper (1955) injected powdered metallic chromium into the pleural cavity of rats, guinea pigs, and mice and observed no significant increase in tumor incidence, either at the injection site or in other organs. Payne (1960) implanted chromite roast, from which the soluble sodium chromate was extracted, into the pleural cavity of 35 rats. None of the 35 control animals developed tumors, and three of the treated animals developed tumors at the implantation site. In an earlier study, Hueper (1958) using chromite roast not leached of sodium chromate, none of the 25 treated male Bethesda rats developed implantation site tumors during 24 mo; however, the early deaths of nine of the treated animals decreased the number of animals at risk. Hueper and Payne (1962) noted that no implantation site tumors were observed in 42 rats during a 24-mo period following eight implantations of 25 mg of trivalent chromium acetate in gelatin over a 13-mo period.

Baetjer et al. (1959) chronically exposed three strains of mice (Strain A, Swiss, and C57Bl) and mixed-breed rats to approximately 1 mg chromium dust/m³, 4 hours/day, 5 days/week over a range of 16-58 weeks, and reported no increase in the incidence of lung tumors with respect to untreated controls. Similar results were obtained by Steffee and Baetjer (1965) for Wistar rats, rabbits, and guinea pigs exposed to chromium dust.

Laskin (1972) exposed rats and hamsters to calcium chromate aerosol at a level of 2 mg/m³ (0.67 mg Cr(VI)/m³) for 589 days out of an 891-day study. Although some laryngeal hyperplasias and metaplasias were observed in both species tested, details pertaining to controls were not given in the available review.

4.2.4. Subchronic Inhalation Studies

Data from animal studies identify the respiratory tract as the primary target of chromium toxicity following inhalation. Glaser et al. (1985) exposed 5-week-old male Wistar rats to aerosols of sodium dichromate at concentrations ranging from 0.025 to 0.2 mg Cr(VI)/m³, 22 hr/day in subacute (28 day) or subchronic (90 day) protocols. Subacute and subchronic exposures to Cr(VI) aerosol concentrations resulted in a positive correlation between exposure dose and significant effects on alveolar macrophages and immunological function. Inhalation of Cr(VI) aerosols stimulated the humoral immune system. Differences in the mean total serum

immunoglobulin were significant at exposures above 0.025 mg/m³, while exposures to aerosol concentrations greater than 0.1 mg/m³ resulted in depression of the immune system stimulation. The primary antibody response to the β -cell-dependent antigen sheep red blood cell was elevated in a chromium time- and dose-dependent manner. The immune stimulating effect of subchronic exposure to an aerosol with 0.05 mg/m³ chromium was not reversed after 2 months of fresh air regeneration. Subchronic exposure to 0.2 mg/m³ chromium resulted in depression of the immune-stimulating effect relative to the response at 0.05 mg/m³. The spleen T-lymphocyte subpopulation was also stimulated by subchronic exposure to 0.2 mg/m³ chromium. Bronchoalveolar lavage (BAL) cell counts were significantly decreased following subchronic exposure to levels above 0.025 mg/m³ chromium, though it was not clear whether the effectiveness of the lavagability of the cells was altered at the higher dose levels. The number of lymphocytes and granulocytes showed a slight but significant increase in the lavage fluids of the of the subacute and subchronically exposed groups. At subacute exposure concentrations up to 0.05 mg/m³ the phagocytic activity of the alveolar macrophages increased; however, subchronic exposure at 0.2 mg/m³ decreased this function significantly, complicating the interpretation of this result. Following subacute exposure to 0.2 mg/m³ chromium, reductions in macrophage cell counts and phagocytic activities correlate with an observed lower clearance of inhaled iron oxide. Inhaled chromium was found to preferentially accumulate in the lung following exposure to chromate aerosols. Lung and spleen weights were significantly increased ($p < 0.005$) after both subacute and subchronic inhalation of chromate aerosols at concentrations greater than 0.025 mg/m³. Serum contents of triglycerides and phospholipids differed significantly from controls ($p < 0.05$) in rats exposed subchronically to 0.2 mg/m³ chromate.

Glaser et al. (1990) presented a paper at the Second European Meeting of Environmental Hygiene that reported exposure of 8-week-old male Wistar rats to sodium dichromate at 0.05, 0.1, 0.2, and 0.4 mg Cr(VI)/m³ 22 hr/day, 7 days/week for 30-90 days. Chromium-induced effects occurred in a strong dose-dependent manner. The authors observed obstructive respiratory dyspnea and reduced body weight following subacute exposure at the higher dose levels. The mean white blood cell count was increased at all doses ($p < 0.05$) and was related to significant dose-dependent leukocytosis following subacute exposures. Mean lung weights were significantly increased at exposure levels of 0.1 mg/m³ following both the subacute and subchronic exposures. Accumulation of macrophages was seen in all of the exposure groups and was postulated to be a chromium-specific irritation effect that accounted for the observed increases in lung weights.

Focal inflammation was observed in the upper airways following the subchronic exposure. BAL analyses provided more detailed information on the nature of the dichromate-induced irritation effect. BAL albumin was increased following the subacute exposure, and was taken to indicate exudation into the alveolar region as an early irritation effect. The mean protein content of the cell-free lavage fluid was significantly increased in a dose-dependent fashion after the subacute and subchronic exposures. However, protein levels returned to control levels following a recovery period. Cytosolic lactate dehydrogenase and the number of mononuclear macrophages were also elevated following the subacute and subchronic exposures, particularly at the highest dose levels. The enzyme activity and number of macrophages returned to the control level following the recovery period. The authors concluded that chromium inhalation induced

pneumocyte toxicity and suggested that inflammation is essential for the induction of most chromium inhalation effects and may influence the carcinogenicity of Cr(VI) compounds (Glaser et al., 1990).

Johansson et al. (1980) exposed groups of four rabbits to chromium dust at concentrations of 3.1 mg/m^3 and 0.6 mg/m^3 for 5 days/week, 6 hours/day for 4 weeks. Macrophages collected from rabbits exposed to the higher concentration of chromium phagocytized significantly more chromium particles than the controls, though the number of nonviable macrophages was less than 3%.

Johansson et al. (1986) exposed groups of rabbits to aerosols of hexavalent ($0.9 \text{ mg Cr[VI]/m}^3$ as Na_2CrO_4) or trivalent ($0.6 \text{ mg Cr[III]/m}^3$ as $\text{Cr[NO}_3\text{]}_3$) chromium 5 days/week, 6 hours/day for four to six weeks. The number of macrophages obtained from the lungs of the rabbits exposed to Cr(VI) was significantly increased. While the numbers of macrophages from rabbits exposed to Cr(III) were not increased, striking morphological changes were observed, including round dark chromium-rich inclusions in the cytoplasm, an increased number of cells with a smooth, inactive cell surface, enlarged Golgi apparatus, and a tendency toward elongated cell shape. The macrophages from rabbits exposed to Cr(VI) showed less marked morphological changes than those exposed to Cr(III).

Lee et al. (1988) exposed groups of 30 male and 30 female rats to 0.5 mg/m^3 or 25 mg/m^3 CrO_2 (IV) 6 hr/day, 5 days/week for 2 years. There were no compound-related differences in weight gain between exposed and control groups and no exposure-related mortality in any exposed group. There were no compound-related lesions in the vital organs and tissues other than in the lungs of exposed rats. Dust-laden alveolar macrophages with slight Type II pneumocyte hyperplasia were noted following exposure at 0.5 mg/m^3 . Inhaled particles were deposited mainly in the alveoli adjacent to the alveolar ducts and the dust particles appeared as dense particles and were phagocytized by intraalveolar macrophages. Exposure at 25 mg/m^3 was suggested to have overwhelmed the lung clearance mechanisms and resulted in significant increases in dust-laden macrophages, bronchoalveolar cell hyperplasia with foamy macrophage response, and cholesterol granuloma. The mechanism of action was not confirmed in the study, and the observation of dust particles in the alveolar macrophages is not necessarily indicative of overloading of the lung clearance mechanism. At 24 mo, the dust deposition and effects were increased significantly, with severe dust-laden macrophages, dust deposition in peribronchial lymphoid tissue, hyperplasia of Type II pneumocytes, and collagenized fibrosis occurring in 100% of all lung tissues examined in either gender. Two female rats developed well-differentiated cystic keratinizing squamous cell carcinomas with no tumor metastasis. The tumors were not characterized as neoplastic lesions.

Mice exposed to 1.81 or 3.63 mg/m^3 Cr(VI) as CrO_3 for 1 year developed nasal septal perforation, loss of cilia, and metaplasia of the lung, trachea, and bronchus (Adachi, 1987; Adachi et al., 1986)

4.3. REPRODUCTIVE/DEVELOPMENTAL STUDIES

4.3.1. Oral Studies

High doses of Cr(VI) compounds have been reported to cause developmental toxicity in mice. Trivedi et al. (1989) exposed mice to 250, 500, and 1,000 ppm potassium dichromate daily through drinking water during the entire gestational period. The authors reported decreased fetal weight, increased resorptions, and increased abnormalities (tail kinking, delayed ossification of the cranium) in exposed mice. The medium- and high-dose groups registered significant reductions in body weight gain when compared to controls. The most significant finding of the study was the complete absence of uterine implantation in the high-dose group. The 250 and 500 ppm dose groups also showed significant incidences of resorption as compared to controls. The authors observed significant increases in preimplantation and postimplantation losses and dose-dependent reductions in total weight and crown-rump length in the lower dose groups. Additional effects included treatment-related increases in abnormalities in the tail, wrist forelimbs and subdermal hemorrhagic patches in the offspring.

Zahid et al. (1990) fed BALB/C albino Swiss mice trivalent (chromium disulfate) and hexavalent (potassium dichromate) chromium at concentrations of 100, 200, and 400 ppm for 35 days in the diet. The authors stated that the exposure groups included seven animals per group, and an additional seven animals were used as controls, though conflicting summaries of the actual group sizes are presented throughout the report. Following the treatment, the authors examined the testes and epididymis of the animals. The epididymis was weighed and minced suspended in buffered formalin. Sperm counts were then subsequently determined and sperms were examined for morphological abnormalities. Testes were fixed with Bouin's fluid for 1 week and were subsequently sectioned to 0.6 micron thickness and stained with haematoxylin and eosin for histological examination. Ten sections were chosen randomly from the anterior, middle, and posterior parts of each testis and studied. One seminiferous tubule was chosen and examined to determine the cellular stages of spermatogenesis and the number of degenerated tubules. Statistical analyses of the data were conducted using the *t*-test between means and the 2×2 contingency chi-square test between percentages. The authors reported deleterious effects on the male mouse testes, including ambiguous levels of degeneration in the outermost cellular layers of the seminiferous tubules, reduced (or absent) spermatogonia per tubule, accumulation of germ cells in the resting spermatocytes stage, reduced sperm count in the epididymis, and increased percentage of morphologically abnormal sperms at all dose levels. The authors concluded that the small but significant increase of hexavalent chromium in the testes of fed animals induced significant degeneration.

Serious questions have been raised regarding the design and conduct of this study (Finley et al., 1993; NTP 1996a,b, 1997). The methods utilized in the Zahid et al. study are considered to be insufficient to identify spermatogonia, likely generated nonreproducible counts of epididymal sperm, and resulted in the biologically implausible conclusion of reduction in spermatogonia numbers concurrent with unchanged spermatocyte and spermatid numbers. Additional questions have been raised with regard to uncertainties regarding the actual groupings of animals used and the statistical analysis of the data.

The National Toxicology Program recently conducted a three-part study to investigate oral ingestion of hexavalent chromium in experimental animals (NTP, 1996a,b, 1997). The study included a determination of the potential reproductive toxicity of potassium dichromate in Sprague-Dawley rats, a repeat of the study of Zahid et al. (1990) using BALB/C mice, and a Reproductive Assessment by Continuous Breeding study in BALB/C mice.

The study in the Sprague-Dawley rat (NTP, 1996a) was conducted in order to generate data in a species commonly used for regulatory studies. Groups of 24 males and 48 females were exposed to 0, 15, 50, 100, or 400 ppm potassium dichromate daily in the diet for 9 weeks followed by a recovery period of 8 weeks. Six male and 12 female rats were sacrificed after 3, 6, or 9 full weeks of treatment or after the full recovery period. Animals were examined for body weights; feed and water consumption; organ weights; microscopic evaluation of the liver, kidney, and ovaries; hematology; histology of the testis and epididymus for Sertoli nuclei and preleptotene spermatocyte counts in Stage X or XI tubules; and chromatin analysis. No treatment-related hematology findings were reported except for slight decreases in MCV and MCH values in the male and female treatment groups receiving 400 ppm potassium dichromate (24 mg/kg-day). While the trends in MCV and MCH were not large and were within the reference ranges (Charles River Laboratories, 1993), they are consistent with the findings of the companion studies in BALB/C mice (see below) and were characterized by the authors as suggestive of a potential bone marrow/erythroid response. The authors considered the 100 ppm (6 mg/kg-day) dose group to be representative of the NOAEL for the study.

The reproductive study in BALB/C mice (NTP, 1996b) was conducted to reproduce the conditions utilized by Zahid et al. (1990) in their examination of comparative effects of trivalent and hexavalent chromium on spermatogenesis of the mouse. Groups of 24 male and 48 female BALB/C mice were exposed to 0, 15, 50, 100, or 400 ppm potassium dichromate in the diet for 9 weeks followed by a recovery period of 8 weeks. Six male and 12 female mice were sacrificed after 3, 6, or 9 full weeks of treatment or after the full recovery period. Animals were examined for body weights; feed and water consumption; organ weights; microscopic evaluation of the liver, kidney, and ovaries; hematology; histology of the testis and epididymus for Sertoli nuclei and preleptotene spermatocyte counts in Stage X or XI tubules; and chromatin analysis. Treatment-related effects included a slight reduction in the mean body weights in the 400 ppm males and the 100 ppm females, a slight increase in food consumption at all dose levels, a slight decrease in MCV and MCH at 400 ppm, and cytoplasmic vacuolization of the hepatocyte at 50, 100 and 400 ppm. None of the effects on spermatogenesis reported by Zahid et al. (1990) were observed in this study. On the basis of the cytoplasmic vacuolization of the hepatocyte in the 50, 100, and 400 ppm dose groups, the authors selected 15 ppm (4 mg/kg-day) as the NOAEL.

The potential reproductive toxicity of potassium dichromate was further evaluated in BALB/C mice using the Reproductive Assessment by Continuous Breeding protocol (NTP, 1997). In the continuous breeding phase of the study, groups of 20 male and female pairs of animals (F_0) were exposed to dose levels of 0, 100, 200, and 400 ppm potassium dichromate, based on the previous study of reproductive effects in BALB/C mice. Litters born after the continuous breeding phase (F_1) received the same concentrations of potassium dichromate as their F_0 parents. F_1 animals were used for assessment of second-generation reproductive toxicity.

At sexual maturity, 20 control animals of each sex and 20 treated animals of each sex in each dose group were selected as breeding pairs (avoiding sibling matings), cohabitated for 7 days, and then separated. Offspring were counted and examined for terminal body and organ weights and received sperm and tissue analysis. The NTP studies were designed to repeat the findings of Zahid using methods of greater rigor and definition, but were unable to do so. The reproductive assessment indicated that potassium dichromate administered at 100, 200, or 400 ppm in the diet to male and female BALB/C mice is not a reproductive toxicant in either sex. Fertility and the pregnancy index (number delivering/number cohabitated) were not affected by continued exposure to potassium dichromate. No treatment-related differences were observed in the mean average litters per pair, number of live pups per litter, proportion of pups born alive, sex ratio, absolute live pup weight, or adjusted live pup weight. Mean body weights of the high-dose F₀ and F₁ animals were slightly decreased relative to controls, and mean food consumption in the F₁ animals was increased relative to controls. Mean absolute liver weights in the high-dose group F₀ animals were decreased relative to controls. Treatment-related changes were observed in the hematology data for the F₁ animals. The MCV was slightly decreased in the high-dose males, and the MCH was slightly decreased in the female animals in all dose groups. The authors suggested that the NOAEL was not established in this study because of the slight decrease in MCH in the females of the 100 ppm (22.4 mg/kg-day) dose group.

Junaid et al. (1996) exposed female Swiss albino mice to 250, 500, or 750 ppm potassium dichromate in drinking water to determine the potential embryotoxicity of hexavalent chromium during days 6-14 of gestation. No notable changes in behavior or clinical signs were observed in the control or treated dams. Chromium levels in blood, placenta, and fetus increased in a dose-dependent fashion over the course of the study. The authors reported retarded fetal development and embryo- and fetotoxic effects including reduced fetal weight, reduced number of fetuses (live and dead) per dam, and higher incidences of stillbirths and postimplantation loss in the 500 and 750 ppm dosed mothers. Significantly reduced ossification in nasal, frontal, parietal, interparietal, caudal, and tarsal bones was observed in the high-dose group, while reduced ossification in only the caudal bones was observed in the 500 ppm dose group. Based on the body weight of the animals (30 +/- 5 g) and the drinking water ingested by the animals in the 250 ppm dose group (8.0 ml/mouse/day), the dose level in the 250 ppm group can be identified as 67 mg/kg-day.

Kanojia et al. (1996) exposed female Swiss albino rats to 250, 500, or 750 ppm potassium dichromate in drinking water to determine the potential teratogenicity of hexavalent chromium pregestationally for 20 days. No notable changes in behavior or clinical signs were observed in the control or treated dams. Chromium levels in blood, placenta, and fetus were significantly increased in the dams of the 500 and 750 ppm dose groups. The authors reported a reduced number of corpora lutea and implantations, retarded fetal development, and embryo- and fetotoxic effects including reduced number of fetuses (live and dead) per dam and higher incidences of stillbirths and postimplantation loss in the 500 and 750 ppm dosed mothers. Significantly reduced parietal and interparietal ossification was observed in the high-dose group. Based on the body weight of the animals (175 +/- 25 g) and the drinking water ingested by the animals in the 250 ppm dose group (26 ml/mouse/day) the dose level in the 250 ppm group can be identified as 37 mg/kg-day.

Elbetieha and Al-Hamood (1997) examined fertility following potassium dichromate exposures in mice at concentrations considerably greater than those used by NTP. Sexually mature male and female mice were exposed to 1,000, 2,000, 4,000, or 5,000 mg/L potassium dichromate in drinking water for 12 weeks. The effects of the exposures on fertility was examined at 140 days. No mortality or clinical signs of toxicity were reported in any group of male or female mice exposed at any concentration in the experiment. Exposure of male mice to hexavalent chromium compounds for 12 weeks had adverse impacts on the male reproductive system and fertility, though the mating capability of the mice was not affected. Fertility was significantly reduced in males exposed to 5,000 mg/L potassium dichromate. Testes weights were significantly increased in the males exposed in the 2,000 and 5,000 mg/L dose groups, while seminal vesicle and preputial gland weights were significantly reduced in the 5,000 mg/L exposed males. The numbers of implantation sites and viable fetuses were significantly reduced in females impregnated by males exposed to 2,000 and 4,000 mg/L. The numbers of implantations and viable fetuses were significantly reduced in pregnant females exposed to 2,000, 4,000, and 5,000 mg/L of the hexavalent chromium compound.

The findings of Junaid et al. (1996) and Kanojia et al. (1996) are consistent with those of Trivedi et al. (1989), and studies suggest the presence of embryotoxic and fetotoxic effects of potassium dichromate following oral exposures in mice and rats. The studies utilized similar dose levels provided in the drinking water of female mice and rats. The dose levels are similar to those used by the NTP study, which demonstrated no reproductive effects following administration of potassium dichromate in the diet. It cannot be determined whether the lack of reproductive toxicity demonstrated in the NTP studies are reflective of the reduced bioavailability of hexavalent chromium provided in the diet in comparison to that provided in drinking water, or whether the NTP studies identified a NOAEL for reproductive effects.

4.3.2. Inhalation Studies

No developmental effects were reported in rats exposed to 0.2 mg/m³ Cr(VI) as sodium dichromate for three generations (Glaser et al., 1984). No histopathological effects of the testes were reported following exposure of rats to 0.2 mg/m³ Cr(VI) as sodium dichromate for 28 or 90 days (Glaser et al., 1985) or 0.1 mg/m³ Cr(VI) as sodium dichromate for 18 mo (Glaser et al., 1986, 1988).

4.4. OTHER STUDIES

4.4.1. Contact Dermatitis

Chromium is one of the most common contact sensitizers in males in industrialized countries (Fowler, 1990; Cronin, 1980) and is associated with occupational exposures to numerous materials and processes, including chromeplating baths, chrome colors and dyes, cement, tanning agents, wood preservatives, anticorrosive agents, welding fumes, lubricating oils and greases, cleaning materials, and textiles and furs (Burrows and Adams, 1990; Polak et al., 1973). Solubility and pH appear to be the primary determinants of the capacity of individual

chromium compounds to elicit an allergic response (Fregert, 1981; Polak et al., 1973). The low solubility Cr(III) compounds are much less efficient contact allergens than Cr(VI) (Spruit and van Neer, 1966).

Dermal exposure to chromium has been demonstrated to produce irritant and allergic contact dermatitis (Bruynzeel et al., 1988; Polak, 1983; Cronin, 1980; Hunter, 1974). Primary irritant dermatitis is related to the direct cytotoxic properties of chromium, while allergic contact dermatitis is an inflammatory response mediated by the immune system. Allergic contact dermatitis is a cell-mediated immune response that occurs in a two-step process. In the first step (induction), chromium is absorbed into the skin and triggers an immune response (sensitization). Sensitized individuals will exhibit an allergic dermatitis response when exposed to chromium above a threshold level (Polak, 1983). Induction is generally considered to be irreversible. Chromium allergic dermatitis is characterized by symptoms of erythema, swelling, papules, small vesicles, dryness, scaling, and fissuring (Adams, 1990; MacKie, 1981).

4.4.2. Toxicant Interactions

Potassium dichromate has been reported to potentiate the effects of the nephrotoxins, mercuric chloride, citrinin, hexachlorobutadiene, and maleic acid (ATSDR, 1993). The genotoxicity of hexavalent chromium has also been shown to be altered in the presence of other compounds, including ascorbic acid and vitamin E and thiol compounds (Susa et al., 1994). Vitamin B₂ has been reported to enhance the cytotoxicity of sodium chromate (ATSDR, 1993).

4.4.3. Genotoxicity

Hexavalent chromium is rapidly taken up by cells through the sulfate transport system (Sugiyama, 1992). Once inside the cell, Cr(VI) is quickly reduced to the trivalent form by cellular reductants, including ascorbic acid, glutathione, and flavoenzymes, such as cytochrome P-450 glutathione reductase, and riboflavin. The intracellular reduction of Cr(VI) generates reactive chromium V and chromium IV intermediates as well as hydroxyl free radicals ($\bullet\text{OH}$) and singlet oxygen ($^1\text{O}_2$). A variety of DNA lesions are generated during the reduction of Cr(VI) to Cr(III), including DNA strand breaks, alkali-labile sites, DNA-protein and DNA-DNA crosslinks, and oxidative DNA damage, such as 8-oxo-deoxyguanosine. The relative importance of the different chromium complexes and oxidative DNA damage in the toxicity of Cr(VI) is unknown.

Hexavalent chromium has been shown to be genotoxic only in the presence of appropriate reducing agents in vitro or in viable cell systems in vitro or in vivo. Hexavalent chromium has been shown to be mutagenic in bacterial systems in the absence of a mammalian activating system (Venitt and Levy, 1974; Nishioka, 1975; Nakamuro et al., 1978; Green et al., 1976; Kanematsu et al., 1980; Lofroth and Ames, 1978; Newbold et al., 1979; Bonatti et al., 1976; Fukunaga et al., 1982), and not mutagenic when a mammalian activating system is present (Lofroth, 1978; Petrilli and DeFlora, 1977, 1978a,b). Hexavalent chromium is also mutagenic in eukaryotic test systems (Bonatti et al., 1976; Newbold et al., 1979; Fukunaga et al., 1982) and clastogenic in cultured mammalian cells (Raffetto, 1977; Levis and Majone, 1979; Umeda and

Nishimura, 1979; Tsuda and Kato, 1977; Newbold et al., 1979; Nakamuro et al., 1978; Stella et al., 1982; Ohno et al., 1982; Gomez-Arroyo et al., 1981; Wild, 1978; Sarto et al., 1982). Hexavalent chromium in the presence of glutathione has been demonstrated to produce genotoxic DNA adducts that inhibit DNA replication and are mutagenic (Snow, 1994).

4.5. SYNTHESIS AND EVALUATION OF MAJOR NONCANCER EFFECTS

4.5.1. Oral Studies

4.5.1.1. *Human Studies*

Cr(VI) is considerably more toxic than Cr(III). A cross-sectional study reported the effects of environmental contamination of well water adjacent to a chromium alloy plant. Cr(VI) concentrations were reported as 20 mg/L, with an estimated exposure dose of 0.57 mg/kg-day (Zhang and Li, 1987) No lower dose levels were reported in this study. Reported effects included oral ulcers, diarrhea, abdominal pain, indigestion, vomiting, leukocytosis, and presence of immature neutrophils. The single high dose level reported in the study limits its usefulness for quantitative risk assessment purposes.

Other reports of toxic effects in humans are limited to case reports from accidental poisonings. Some Cr(VI) compounds are potent oxidizing agents (such as potassium tetrachromate and chromium trioxide) and are thus strong irritants of mucosal tissue. Effects included metabolic acidosis, acute tubular necrosis, kidney failure, and death (Saryan and Reedy, 1988).

4.5.1.2. *Animal Studies*

Only one chronic study pertaining to the oral toxicity of hexavalent chromium was located in the available literature. Anwar et al. (1961) exposed dogs orally (2 dogs/group) to potassium chromate in drinking water for 4 years. No effects were observed with regard to gross and microscopic analysis of all major organs, urinalysis, and weights of spleen, liver, and kidney. A NOEL of 0.31 mg potassium chromate/kg/day can be established from this study. The small group size in this study limits its usefulness for quantitative risk assessment purposes.

Mackenzie et al. (1958) exposed groups of male and female rats to potassium dichromate (0-25 ppm of hexavalent chromium) in drinking water for 1 year. No effects were observed at any level of treatment, and a NOEL of 2.5 mg/kg-day can be established based on body weight, gross external condition, histopathological analysis, and blood chemistry.

Junaid et al. (1996) exposed female Swiss albino mice to 250, 500, or 750 ppm potassium dichromate in drinking water to determine the potential embryotoxicity of hexavalent chromium during days 6-14 of gestation. The authors reported retarded fetal development and embryo- and fetotoxic effects including reduced fetal weight, reduced number of fetuses (live and dead) per dam, and higher incidences of stillbirths and postimplantation loss in the 500 and 750 ppm dosed

mothers. Significantly reduced ossification in bones was also observed in the medium- and high-dose groups. Based on the body weight of the animals (30 +/- 5 g) and the drinking water ingested by the animals in the 250 ppm dose group (8.0 ml/mouse/day), the dose level in the 250 ppm group can be identified as 67 mg/kg-day.

Kanojia et al. (1996) exposed female Swiss albino rats to 250, 500, or 750 ppm potassium dichromate in drinking water to determine the potential teratogenicity of hexavalent chromium pregestationally for 20 days. The authors reported a reduced number of corpora lutea and implantations, retarded fetal development, and embryo- and fetotoxic effects including reduced number of fetuses (live and dead) per dam and higher incidences of stillbirths and postimplantation loss in the 500 and 750 ppm dosed mothers. Significantly reduced parietal and interparietal ossification was observed in the high-dose group. Based on the body weight of the animals (175 +/- 25 g) and the drinking water ingested by the animals in the 250 ppm dose group (26 ml/mouse/day), the dose level in the 250 ppm group can be identified as 37 mg/kg-day.

Elbetieha and Al-Hamood (1997) exposed sexually mature male and female mice to 1,000, 2,000, 4,000, or 5,000 mg/L potassium dichromate in drinking water for 12 weeks. The effects of the exposures on fertility was examined at 140 days. The authors reported adverse impacts on the male reproductive system and fertility, though the mating capability of the mice was not affected. Testes weights were significantly increased in the males exposed in the 2,000 and 5,000 mg/L dose groups, while seminal vesicle and preputial gland weights were significantly reduced in the 5,000 mg/L exposed males. The number of implantation sites and viable fetuses was significantly reduced in females impregnated by males exposed to 2,000 and 4,000 mg/L, and the numbers of implantations and viable fetuses was significantly reduced in pregnant females exposed to 2,000, 4,000, and 5,000 mg/L of the hexavalent chromium compound. Information regarding the amount of water consumed by the animals was not provided in this study.

4.5.2. Inhalation Studies

4.5.2.1. Human Studies

4.5.2.1.1. Respiratory tract effects. Three studies on chromeplaters provide some quantitative information on upper respiratory irritation after exposure to Cr(VI) as chromic acid. In the study of Cohen et al. (1974), nasal ulcers and perforations were associated with total chromium concentrations of 1.4 to 43.9 $\mu\text{g}/\text{m}^3$, averaging 7.1 $\mu\text{g}/\text{m}^3$, and Cr(VI) concentrations of 0.09 to 9.1 $\mu\text{g}/\text{m}^3$, averaging 2.9 $\mu\text{g}/\text{m}^3$. Ninety-five percent of the 37 workers studied exhibited pathologic changes in nasal mucosa in a concentration-duration response. More than half of the workers employed less than 1 year had nasal pathology that was more severe than simple redness of the nasal mucosa. Almost all the workers (35 of 37) employed longer than 1 year had nasal tissue damage. The authors noted the lack of good industrial hygiene practices, implicating direct contact, such as touching of the nose with chromium-contaminated hands, as a potentially important route of exposure. A subsequent study by Lucas and Kramkowski (1975) revealed similar results. Cr(VI) concentrations ranged from 1 to 20 $\mu\text{g}/\text{m}^3$, averaging 4 $\mu\text{g}/\text{m}^3$. The authors attributed the nasal pathology primarily to direct contact. Lindberg and Hedenstierna

(1983) also found similar effects on nasal pathology and subjective symptoms. They reported reddening of the nasal mucosa at 1 to 2 $\mu\text{g}/\text{m}^3$, and nasal irritation (chronic and nasal septal ulceration and perforation) in two-thirds of the subjects exposed to concentrations of 2 to 20 $\mu\text{g}/\text{m}^3$. All workers with nasal ulceration had been exposed to chrome acid mist, which contained Cr(VI) at 20 $\mu\text{g}/\text{m}^3$, or greater than 20 $\mu\text{g}/\text{m}^3$ near the baths. Changes in pulmonary function (vital capacity and forced expiratory volume) were seen at Cr(VI) exposures greater than 2 $\mu\text{g}/\text{m}^3$.

4.5.2.1.2. Renal effects. Exposure to Cr(VI) at concentrations as low as 4 to 6 $\mu\text{g}/\text{m}^3$ has been reported to result in elevated excretion of β -2-microglobulin (Lindberg and Vesterberg, 1983b). The effect may be reversible because former chromeplaters did not have an elevated concentration of either β -2-microglobulin or albumin in their urine. Saner et al. (1984) did not find increased urinary β -2-microglobulin levels in tannery workers in comparison to referent control workers. However, urinary chromium concentrations in the Saner et al. study were likely distinctly lower than those in the study of Lindberg and Vesterberg.

In summary, effects on the airways and kidney have been observed in chromeplaters exposed subchronically to chromic acid mist containing Cr(VI) in air at concentrations greater than 1 $\mu\text{g}/\text{m}^3$. Such effects include reddening of nasal mucosa, nasal irritation (ulceration, perforation), changes in pulmonary function, and renal proteinuria. Many of the available studies lack quantitative concentration-response data on chromium health effects suitable for quantitative risk assessment.

4.5.2.2. Animal Studies

Data from studies in rats, mice, and rabbits identify the respiratory tract as the primary target of chromium toxicity following inhalation. Glaser et al. (1985) exposed rats to 0-0.2 mg Cr(VI)/ m^3 22 hr/day, 7 days/week for 90 days. The authors reported increased lung and spleen weight, and increased macrophage activity and percent lymphocytes in BAL fluid. Glaser et al. (1990) exposed rats to 0-0.4 mg Cr(VI)/ m^3 , 22 hr/day, 7 days/week for 30-90 days and reported hyperplasia, increased lung weight, macrophage infiltration, and LDH in bronchoalveolar lavage fluid (BALF). The authors suggested that inflammation is essential for the induction of most chromium inhalation effects and may influence the carcinogenicity of Cr(VI) compounds.

Rats exposed to 0.5 mg/ m^3 CrO₂ (IV) 6 hr/day, 5 days/week for 2 years produced dust-laden alveolar macrophages with slight Type II pneumocyte hyperplasia. Exposure at 25 mg/ m^3 overwhelmed the lung clearance mechanisms and resulted in significant increases in dust-laden macrophages, bronchoalveolar cell hyperplasia with foamy macrophage response, and cholesterol granuloma (Lee et al., 1988).

Mice exposed to 1.81 or 3.63 mg/ m^3 Cr(VI) as CrO₃ for 1 year developed nasal septal perforation, loss of cilia, and metaplasia of the lung, trachea, and bronchus (Adachi, 1987; Adachi et al., 1986). Epithelial changes of the bronchial tree ranging from necrosis and atrophy to hyperplasia were observed in mice exposed to 4.3 Cr/ m^3 as CaCrO₄ dust for 18 months (Nettesheim et al., 1971).

Rabbits exposed to chromium dust at 3.1 mg/m³ and 0.6 mg/m³ for 5 days/week, 6 hours/day for 4 weeks phagocytized significantly more chromium particles than the controls, though the number of nonviable macrophages was less than 3% (Johansson et al., 1980). In a subsequent study, rabbits were exposed to aerosols of hexavalent (0.9 mg/m³ Na₂CrO₄) or trivalent (0.6 mg/m³ Cr[NO₃]₃) chromium for 5 days/week, 6 hours/day for 4 to 6 weeks. The number of macrophages obtained from the lungs of the rabbits exposed to Cr(VI) was significantly increased, while striking morphological changes were observed in macrophages of rabbits exposed to Cr(III) (Johansson et al., 1986).

4.6. WEIGHT-OF-EVIDENCE EVALUATION AND CANCER CHARACTERIZATION

Applying the criteria outlined in the Guidelines for Carcinogen Risk Assessment (U.S. EPA, 1986) for evaluating the overall weight of evidence for carcinogenicity to humans, hexavalent chromium is most appropriately designated a Group A - Known Human Carcinogen. Using the proposed Guidelines for Carcinogen Risk Assessment (U.S. EPA, 1996), hexavalent chromium is most appropriately designated a known human carcinogen by the inhalation route of exposure on the following basis. The potential carcinogenicity of chromium by the oral route of exposure cannot be determined at this time.

Results of occupational epidemiologic studies of chromium-exposed workers are consistent across investigators and study populations. Dose-response relationships have been established for chromium exposure and lung cancer. Workers in the chromium industry are exposed to both Cr(III) and Cr(VI) compounds. Because only Cr(VI) has been found to be carcinogenic in animal studies, however, data support only the classification of Cr(VI) as a human carcinogen.

Animal data provide suggestive evidence of the carcinogenicity of hexavalent chromium. Hexavalent chromium compounds have produced the following tumor types in animal assays: lung tumors following inhalation of aerosols of sodium chromate and pyrolyzed Cr(VI)/Cr(III) oxide mixtures in rats, lung tumors following intratracheal administration of sodium dichromate in rats, intrapleural implant site tumors for various Cr(VI) compounds in rats, intrabronchial implantation site tumors for various Cr(VI) compounds in rats, intramuscular injection site tumors in rats and mice, and subcutaneous injection site sarcomas in rats. Inflammation is considered to be essential for the induction of most chromium inhalation effects and may influence the carcinogenicity of Cr(VI) compounds (Glaser et al., 1985).

In vitro data are suggestive of a potential mode of action for hexavalent chromium carcinogenesis. Cr(VI) readily passes through cell membranes and is rapidly reduced intracellularly to generate reactive Cr(V) and Cr(IV) intermediates and reactive oxygen species. The reactive oxygen species may interact with DNA to form premutagenic lesions. Hexavalent chromium has been shown to be mutagenic in bacterial assays, yeasts, and V79 cells, and Cr(VI) compounds decrease the fidelity of DNA synthesis in vitro and produce unscheduled DNA synthesis as a consequence of DNA damage. Chromate has been shown to transform both primary cells and cell lines.

IARC (1990) concluded that there is sufficient evidence of respiratory carcinogenicity in humans occupationally exposed during chromate production. Animal data were considered supportive of the epidemiological data; however, the relative contributions to carcinogenic risk of metallic chromium, trivalent chromium, hexavalent chromium, or soluble versus insoluble chromium compounds could not be elucidated. IARC (1982) classified chromium and chromium compounds as Group I chemicals.

At present, the carcinogenicity of hexavalent chromium by the oral route of exposure cannot be determined. One study of miners in Ontario suggested that exposure to chromium may have been associated with stomach cancer, but other human and animal studies have not reported similar effects.

4.7. OTHER HAZARD IDENTIFICATION ISSUES

4.7.1. Possible Childhood Susceptibility

A number of factors may differentially affect the response of children to toxicants such as Cr(VI). These factors include diet and physical environment as well as maturation of physiological and biochemical processes. At present, there is too little information to make any statements about how these factors may specifically affect the toxicological responses of Cr(VI) in children, be they cancer or noncancer.

4.7.2. Possible Sex Differences

The extent to which men differ from women in susceptibility to chromium toxicity has not been reported. The most significant health effects associated with exposure to Cr(VI) involve the respiratory system and kidney. While effects on the respiratory system are unlikely to differ significantly with gender, the effect of gender on kidney toxicity is unknown.

5. DOSE-RESPONSE ASSESSMENTS

5.1. ORAL REFERENCE DOSE (RfD)

5.1.1. Choice of Principal Study and Critical Effect

Relatively few studies were located that addressed the oral toxicity of Cr(VI). One human study located in the literature, Zhang and Li (1987), reported on health effects in Chinese villagers who consumed drinking water from a well contaminated with hexavalent chromium from an alloy plant in Jinzhou. The Jinzhou area is heavily industrialized. In 1965, the well water in a nearby suburban area was found to be stained yellow, presumably because of chromium contamination from a mining operation which had begun operating in 1959. The mining operation was initially conducted in pilot scale, with a poor recovery rate for chromium (24.5%). Full-scale operation began in 1965. At this time, waste water was generated at a rate of

125 pounds/hour and contained concentrations of up to 105 mg/L hexavalent chromium. Waste water was deposited directly into a surface channel. Following sedimentation, the surface water concentration was still in excess of 20 mg/L. In addition to the surface water discharge, the mining operation generated hexavalent chromium-containing steam and a considerable amount of chromium-containing mine tailings. The tailings were stored in an open waste pile, containing approximately 300,000 pounds of waste, covering an area of 50 hectares. The waste pile constituted an additional source of ground water contamination through leaching and surface water runoff. In 1965, more than 28% of the area ground water samples were observed to be contaminated with chromium, with 54% of the samples contaminated at a concentration of 20 mg/L or greater. Ground water samples were found to be contaminated over an area of 10 square kilometers. In 1965, the material in the waste pile was found to contain an average of 1.55% hexavalent chromium. The soil in the vicinity of the waste pile was found to contain an average concentration of hexavalent chromium of 4,700 mg/kg, and 0.3 pounds/day of hexavalent chromium was estimated to leach into the ground water from the waste pile. In addition, irrigation water for the considerable agricultural operation in the vicinity of Jinzhou was contaminated with chromium at concentrations of 0.006-0.739 mg/L. However, concentrations in soil and produce in the agricultural areas were only slightly elevated above the controls.

In 1965, a study of 155 subjects exposed to drinking water at concentrations of approximately 20 mg/L of hexavalent chromium was conducted outside Jinzhou. Subjects were observed to have sores in the mouth, diarrhea, stomach ache, indigestion, and vomiting. Subjects were observed to have elevated white blood cell counts with respect to controls, as well as a higher per capita rate of cancers, including lung cancer and stomach cancer. Precise exposure concentrations, exposure durations, and confounding factors were not discussed, and this study does not provide a NOAEL for the observed effects. However, the study suggests that gastrointestinal effects may occur in humans following exposures to hexavalent chromium at levels of 20 ppm in drinking water (Zhang and Li, 1987).

Several animal studies addressing oral toxicity of hexavalent chromium were located in the literature. Anwar et al. (1961) exposed groups of female dogs (2/group) to up to 11.2 ppm Cr(VI) in drinking water for 4 years with no effect. MacKenzie et al. (1958) exposed groups of Sprague-Dawley rats (16-21/group) to up to 25 ppm Cr(VI) in drinking water for 1 year. No significant adverse effects were seen in any treatment group. Both the Mackenzie et al. (1958) and Anwar et al. (1961) studies are limited by the small number of animals/group and the lack of an observed effect at any dose level. While the MacKenzie et al. study has the additional limitation of being conducted for only 1 year, this study is considered to be more useful for risk assessment because of the identification of a NOAEL value and the larger number of animals per dose group that those available from Anwar et al. (1961).

Elbetieha and Al-Hamood (1997) reported adverse impacts on the male reproductive system and fertility, and reduced numbers of implantations and viable fetuses in pregnant females following exposures to hexavalent chromium. Information regarding the amount of water consumed by the animals was not provided, and this study is not considered useful for this risk assessment.

The National Toxicology Program (NTP 1996a,b, 1997) did not observe reproductive effects in either sex of BALB/C mice or Sprague-Dawley rats following oral exposures to 15 - 400 ppm Cr(VI) in the diet.

Junaid et al. (1996) and Kanojia et al. (1996) exposed female Swiss albino mice and female Swiss albino rats, respectively, to 250, 500, or 750 ppm potassium dichromate in drinking water to determine the potential embryotoxicity of hexavalent chromium during days 6-14 of gestation. The authors reported retarded fetal development and embryo- and fetotoxic effects including reduced fetal weight, reduced number of fetuses (live and dead) per dam, and higher incidences of stillbirths and postimplantation loss in the 500 and 750 ppm dosed mothers. Significantly reduced ossification in bones was also observed in the medium- and high-dose groups. Based on the body weight and the drinking water ingested by the animals in the 250 ppm dose group, the exposure levels in the 250 ppm groups can be identified as 67 mg/kg-day and 37 mg/kg-day in mice and rats, respectively.

The Junaid et al. (1996) and Kanojia et al. (1996) studies utilized doses approximately 10-fold higher than those used in Mackenzie et al (1958), but neither of the reproductive studies identified a clear NOAEL for the embryotoxic effects of hexavalent chromium. Based on the body weight and the drinking water ingested by the animals in the low-dose groups (250 ppm), the LOAELs of 67 mg/kg-day and 37 mg/kg-day can be identified from Junaid et al. (1996) and Kanojia et al. (1996) in mice and rats, respectively. Application of 10-fold uncertainty factor to extrapolate from LOAELs to NOAELs in these studies would generate NOAELs of 6.7 mg/kg-day and 3.7 mg/kg-day, respectively. These extrapolated NOAEL values are similar to, and support the use of, the NOAEL of 2.5 mg/kg-day identified from the study of MacKenzie et al. (1958) for development of the reference dose.

5.1.2. Method of Analysis

MacKenzie et al. exposed groups of eight male and eight female Sprague-Dawley rats to 0.45-11.2 ppm (0.45-11.2 mg/L) hexavalent chromium (as K_2CrO_4) for 1 year in drinking water. The control group (10/sex) received distilled water. A second experiment involved three groups of 12 male and 9 female rats. One group was given 25 ppm (25 mg/L) chromium (as K_2CrO_4), a second received 25 ppm chromium in the form of chromic chloride, and the controls again received distilled water. No significant adverse effects were seen in appearance, weight gain, or food consumption, and there were no pathologic changes in the blood or other tissues in any treatment group. The rats receiving 25 ppm of chromium (as K_2CrO_4) showed an approximate 20% reduction in water consumption. This dose corresponds to 2.5 mg Cr(VI)/kg/day based on actual body weight and water consumption data.

For rats treated with 0-11 ppm (in the diet), blood was examined monthly and tissues (livers, kidneys and femurs) were examined at 6 mo and 1 year. Spleens were also examined at 1 year. The 25 ppm groups (and corresponding controls) were examined similarly, except that no animals were killed at 6 mo. An abrupt rise in tissue chromium concentrations was noted in rats treated with greater than 5 ppm. The authors stated that “apparently, tissues can accumulate considerable quantities of chromium before pathological changes result.” In the 25 ppm

treatment groups, tissue concentrations of chromium were approximately 9 times higher for those treated with hexavalent chromium than for the trivalent group. Similar no-effect levels have been observed in dogs. Anwar et al. (1961) observed no significant effects in female dogs (2/dose group) given up to 11.2 ppm Cr(VI) (as K_2CrO_4) in drinking water for 4 years. The calculated doses were 0.012-0.31 mg/kg of Cr(VI).

5.1.3. RfD Derivation

No effects were reported at any dose level in the MacKenzie et al. study. The highest dose group (25 mg/L) was selected for derivation of the reference dose. Based on the body weight of the rat (0.35 kg) and the average daily drinking water consumption for the rat (0.035 l/day), this dose can be converted to give an adjusted NOAEL of 2.5 mg/kg-day.

The adjusted NOAEL is further modified by two 10-fold uncertainty factors to account for the expected interspecies and interhuman variability in lieu of specific data. An additional threefold uncertainty factor is applied to the adjusted NOAEL to compensate for the less-than-lifetime exposure duration in the MacKenzie et al. study. A threefold modifying factor is applied to address concerns raised by the study of Zhang and Li (1987). The total uncertainty factor applied to the adjusted NOAEL is 900. Application of the uncertainty factor to the adjusted NOAEL of 2.5 mg/kg-day gives the reference dose of 3×10^{-3} mg/kg-day.

5.2. INHALATION REFERENCE CONCENTRATION (RfC)

The inhalation reference concentration (RfC) is based on the assumption that thresholds exist for certain toxic effects such as cellular necrosis, but may not exist for other toxic effects such as carcinogenicity. In general, the RfC is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime.

5.2.1. Choice of Principal Study and Critical Effect

Numerous studies have reported upper respiratory, lower respiratory, and kidney effects in humans and animals following exposures to hexavalent chromium. Of these endpoints, upper and lower respiratory effects appear to be the most sensitive and are discussed in greater detail below.

Three studies have focussed on nasal mucosal irritation, atrophy, and perforation following occupational exposures to chromic acid mists (Cohen et al., 1974; Lucas and Kramkowski, 1975; Lindberg and Hedenstierna, 1983). Of these, the study of Lindberg and Hedenstierna provides the most information on exposure levels and symptoms reported by exposed workers. Respiratory symptoms, lung function, and changes in nasal septum were studied in 104 workers (85 males, 19 females) exposed in chromeplating plants. Workers were interviewed using a standard questionnaire for the assessment of nose, throat, and chest

symptoms. Nasal inspections and pulmonary function testing were performed as part of the study.

The median exposure time for the entire group of exposed subjects (104) in the study was 4.5 years (0.1-36 years). Forty-three subjects exposed almost exclusively to chromic acid experienced a mean exposure time of 2.5 years (0.2-23.6 years). The subjects exposed almost exclusively to chromic acid were divided into a low-exposure group (8 hr TWA below 0.002 mg/m³, N = 19) and high exposure group (8 hr TWA above 0.002 mg/m³, N = 24). Exposure measurements using personal air samplers were performed for 84 subjects in the study on 13 different days. Exposure for the remaining 20 workers was assumed to be similar to that measured for workers in the same area. Nineteen office employees were used as controls for nose and throat symptoms. A group of 119 auto mechanics whose lung function had been evaluated by similar techniques was selected as controls for lung function measurements. Smoking habits of workers were evaluated as part of the study.

At mean exposures below 0.002 mg/m³, 4/19 workers from the low-exposure group complained of subjective nasal symptoms. Atrophied nasal mucosa were reported in 4/19 subjects from this group and 11/19 had smeary and crusty septal mucosa, which was statistically higher than controls. No one exposed to levels below 0.001 mg/m³ complained of subjective symptoms. At mean concentrations of 0.002 mg/m³ or above, approximately one-third of the subjects had reddened, smeary, or crusty nasal mucosa. Atrophy was seen in 8/24 workers, which was significantly different from controls. Eight subjects had ulcerations in the nasal mucosa and five had perforations of the nasal septum. Atrophied nasal mucosa was not observed in any of the 19 controls, but smeary and crusty septal mucosa occurred in 5/19 controls.

Short-term effects on pulmonary function were evaluated by comparing results of tests taken on Monday and Thursday among exposed groups and controls. No significant changes were seen in the low-exposure group or control group. Nonsmokers in the high-exposure group experienced significant differences in pulmonary function measurements from the controls, but the results were within normal limits.

The authors concluded that 8-hour mean exposures to chromic acid above 0.002 mg/m³ may cause a transient decrease in lung function, and that short-term exposures to greater than 0.02 mg/m³ may cause septal ulceration and perforation. Based on the results of this study, a LOAEL of 0.002 mg/m³ can be identified for incidence of nasal septum atrophy following exposure to chromic acid mists in chromeplating facilities. It should be noted that there are significant uncertainties related to the use of this LOAEL for development of an RfC for hexavalent chromium in the environment. There is considerable uncertainty with regard to the relevance of the nasal septum atrophy endpoint observed in the chromeplating industry to exposure to hexavalent chromium in the environment. The effects were observed in chromeplaters exposed to chromic acid mists near the plating baths. Environmental exposures would most likely occur through contact with hexavalent chromium dusts. An additional uncertainty is related to the determination of dose in the Lindberg and Hedenstierna study. Nasal septum atrophy in this study was related to time-weighted average (TWA) exposures to chromic acid. The most significant effects (nasal septum perforation) were observed in workers who

experienced peak excursions to levels considerably greater than the TWA. It is uncertain whether the peak excursion data or the TWA are more appropriate for the determination of dose in this study.

An alternative approach to development of the RfC is to focus on respiratory effects following inhalation of hexavalent chromium particulates. Two studies provide high quality data on lower respiratory effects following exposures to chromium particulates (Glaser et al., 1990; Glaser et al., 1985). Glaser et al. (1990) exposed 8-week-old male Wistar rats to sodium dichromate at 0.05 - 0.4 mg Cr(VI)/m³ 22 hr/day, 7 days/week for 30-90 days. Chromium-induced effects occurred in a strong dose-dependent manner. The authors observed obstructive respiratory dyspnea and reduced body weight following subacute exposure at the higher dose levels. The mean white blood cell count was increased at all doses ($p < 0.05$) and was related to significant dose-dependent leukocytosis following subacute exposures. Mean lung weights were significantly increased at exposure levels of 0.1 mg/m³ following both the subacute and subchronic exposures. Accumulation of macrophages was seen in all of the exposure groups and was postulated to be a chromium-specific irritation effect that accounted for the observed increases in lung weights. Focal inflammation was observed in the upper airways following the subchronic exposure, and albumin and LDH in BALF were increased following the exposure. The authors concluded that chromium inhalation induced pneumocyte toxicity and suggested that inflammation is essential for the induction of most chromium inhalation effects, and may influence the carcinogenicity of Cr(VI) compounds.

Glaser et al. (1985) exposed 5-week-old male Wistar rats to aerosols of sodium dichromate at concentrations ranging from 0.025 to 0.2 mg Cr(VI)/m³, 22 hr/day in subacute (28 day) or subchronic (90 day) protocols. Chromium-induced effects occurred in a dose-dependent manner. Lung and spleen weights were significantly increased ($p < 0.005$) after both subacute and subchronic exposures at concentrations greater than 0.025 mg/m³. Differences in the mean total serum immunoglobulin were also significant at exposures above 0.025 mg/m³, while exposures to aerosol concentrations greater than 0.1 mg/m³ resulted in depression of the immune system stimulation. The immune-stimulating effect of subchronic exposure was not reversed after 2 mo of fresh air regeneration. BAL cell counts were significantly decreased following subchronic exposure to levels above 0.025 mg/m³ chromium. The number of lymphocytes and granulocytes showed a slight but significant increase in the lavage fluids of the subacute and subchronically exposed groups. At subacute exposure concentrations up to 0.05 mg/m³, the phagocytic activity of the alveolar macrophages increased; however, subchronic exposure at 0.2 mg/m³ decreased this function significantly. The spleen T-lymphocyte subpopulation was stimulated by subchronic exposure to 0.2 mg/m³ chromium, and serum contents of triglycerides and phospholipids differed significantly from controls ($p < 0.05$) at this concentration.

Together, these studies provide useful information on chromium exposure-related impacts including lung and spleen weight, lactate dehydrogenase (LDH) in BALF, protein in BALF, and albumin in BALF. The cellular content of BALF is considered representative of initial pulmonary injury and chronic lung inflammation, which may lead to the onset of pulmonary fibrosis (Henderson, 1988). While these studies present dose-dependent results on sensitive indicators of lower respiratory toxicity, potential upper respiratory impacts resulting from the

exposures were not addressed. Glaser et al. (1990) states that the upper respiratory tract was examined, but these data are not reported. In light of the numerous reports of severe upper respiratory impacts following exposure to chromic acid in the occupational setting, the studies of Glaser et al. alone are not considered sufficient to support derivation of an RfC for chromium.

While the studies of Lindberg and Hedenstierna (1983) and Glaser et al. (1985, 1990) are independently considered insufficient for development of an RfC for hexavalent chromium, taken together these offer an approach for development of an RfC.

5.2.2. RfC Derivation

Lindberg and Hedenstierna (1983) will be used to support development of an RfC for upper respiratory effects of chromic acid mists and dissolved hexavalent chromium aerosols, and Glaser et al. (1985, 1990) will be used to support development of an RfC for lower respiratory effects from chromium particulates.

5.2.2.1. *Chromic Acid Mists and Dissolved Hexavalent Chromium Aerosols*

A LOAEL for nasal septum atrophy of $2 \mu\text{g}/\text{m}^3$ chromic acid can be identified based on the results of Lindberg and Hedenstierna (1983). At TWA exposures greater than $2 \mu\text{g}/\text{m}^3$, nasal septum ulceration and perforations occurred in addition to the atrophy reported at lower concentrations. The LOAEL is based on an 8-hour TWA occupational exposure. The LOAEL is adjusted to account for continuous exposure according to the following equation:

$$\text{LOAEL}_c = 2 \mu\text{g}/\text{m}^3 \times (\text{MVho}/\text{MVh}) \times 5 \text{ days}/7 \text{ days}$$

where:

LOAEL_c is the LOAEL for continuous exposure

MVho is the breathing volume for an 8-hour occupational exposure (10 m^3)

MVh is the breathing volume for a 24-hour continuous exposure (20 m^3)

The LOAEL of $2 \mu\text{g}/\text{m}^3$ based on a TWA exposure to chromic acid is converted to a LOAEL for continuous exposure of $0.714 \mu\text{g}/\text{m}^3$. An uncertainty factor of 3 is applied to the LOAEL to extrapolate from a subchronic to a chronic exposure, an uncertainty factor of 3 is applied to account for extrapolation from a LOAEL to a NOAEL, and an uncertainty factor of 10 is applied to the LOAEL to account for interhuman variation. The total uncertainty factor applied to the LOAEL is 90. Application of the uncertainty factor of 90 to the LOAEL of $0.714 \mu\text{g}/\text{m}^3$ generates an RfC for upper respiratory effect of chromic acid mists and dissolved hexavalent chromium aerosols of $0.008 \mu\text{g}/\text{m}^3$.

5.2.2.2. Hexavalent Chromium Dusts

Glaser et al. (1990) exposed male Wistar rats to 0.05-0.4 mg/m³ sodium dichromate 22 hr/day, 7 days/week for 30 or 60 days, or 90 days with a 30-day recovery period. In Glaser et al. (1985), male Wistar rats were exposed to 0.025 - 0.2 mg/m³ sodium dichromate 22 hr/day, 7 days/week for 28 or 90 days. Data were reported on numerous endpoints indicative of lung toxicity. One approach for development of an RfC using these data was offered by Malsch et al. (1994), who generated an inhalation RfC for chromium dusts using a benchmark concentration (BMC) approach. The Agency based its RfC derivation on this approach. After excluding exposures for periods of less than 90 days from the BMC analysis, Malsch et al. (1994) developed BMCs for lung weight, lactate dehydrogenase (LDH) in BALF, protein in BALF, albumin in BALF, and spleen weight. The Malsch et al. (1994) analysis defined the benchmark concentration as the 95% lower confidence limit on the dose corresponding to a 10% relative change in the endpoint compared to the control. Dose-effect data were adjusted to account for discontinuous exposure (22 hr/day) and the maximum likelihood model was used to fit continuous data to a polynomial mean response regression, yielding maximum likelihood estimates of 36 -78 µg/m³ and BMCs of 16 - 67 µg/m³. Malsch et al. (1994) applied dosimetric adjustments and uncertainty factors to the BMCs to determine a RfC based on the following equation:

$$\text{RfC} = \frac{\text{BMC} \times \text{RDDR}}{\text{UF}_A \times \text{UF}_F \times \text{UF}_H}$$

where:

- RfC is the inhalation reference concentration
- BMC is the benchmark concentration (lower 95% confidence limit on the dose corresponding to a 10% relative change in the endpoint compared to the control)
- RDDR is the regional deposited dose ratio to account for pharmacokinetic differences between species
- UF_A is a threefold uncertainty factor to account for pharmacodynamic differences not addressed by the RDDR
- UF_F is a threefold uncertainty factor to account for extrapolating from subchronic to chronic exposures; and
- UF_H is a 10-fold uncertainty factor to account for the variation in sensitivity among members of the human population

The RDDR factor is incorporated to account for differences in the deposition pattern of inhaled hexavalent chromium dusts in the respiratory tract of humans and the Wistar rat test animals (Jarabek et al., 1990). The RDDR of 2.1355 was taken from U.S. EPA (1990), based on the mass median aerodynamic diameter (0.28 µm for dose levels of 50-100 µg/m³ and 0.39 for dose levels of 100-400 µg/m³) and the geometric standard deviation (1.63 for dose levels of 50-100 µg/m³ and 1.72 for dose levels of 100-400 µg/m³) of the particulates reported in Glaser et al. (1990). A 3.16-fold uncertainty factor (midpoint between 1 and 10 on a log scale) was incorporated to account for the pharmacodynamic differences not accounted for by the RDDR. An additional 3.16-fold uncertainty factor was incorporated to account for the less-than-lifetime

exposure in Glaser et al. (1990), and a 10-fold uncertainty factor was applied to account for variation in the human population. A total uncertainty factor of 100 was applied to the BMC in addition to the RDDR.

Glaser et al. (1990) reported that LDH in BALF increased in a dose-dependent fashion from 50 to 400 $\mu\text{g}/\text{m}^3$ sodium dichromate, and this endpoint generated the lowest BMC (16 $\mu\text{g}/\text{m}^3$) and RfC (0.34 $\mu\text{g}/\text{m}^3$). LDH in BALF is considered among the most sensitive indicators of potential lung toxicity (Henderson, 1984, 1985, 1988; Beck et al., 1982; Venet et al., 1985), as LDH is found extracellularly after cell damage and BALF is the closest site to the original lung injury. LDH in BALF may also reflect chronic lung inflammation, which may lead to pulmonary fibrosis through prevention of the normal repair of lung tissue (Henderson, 1988).

Several uncertainties must be addressed with regard to the BMC and RfC developed by Malsch et al. (1994). Potentially important endpoints including upper airway effects and potential renal or immunological toxicity were not addressed in the Glaser et al. (1985, 1990) studies and could not be included in the BMC analysis. While LDH in BALF resulted in the lowest BMC and RfC, several of the effects noted in Glaser et al. (1985, 1990) can be considered indicative of an inflammatory response, and might be equally suited to development of the RfC. In addition, the threefold uncertainty factor accounting for the use of a subchronic study may not be sufficiently protective for long-term effects. While the analysis acknowledged the importance of particle size and airway deposition in the development of the RDDR, the potential impact of different particle sizes in respiratory toxicity by hexavalent chromium particulates was not addressed.

Several of these uncertainties have been conservatively addressed in the analysis of Malsch et al. (1994). LDH in BALF generated the lowest estimate of the BMC from the effects noted by Glaser et al. (1985, 1990). This effect can be considered to be indicative of cell damage that occurs prior to fibrosis, as LDH appears in BALF following cell lysis. While other endpoints considered in the Malsch et al. (1994) analysis demonstrated a relatively better curve fit than LDH in BALF, the model generated a conservative fit in the data that is unlikely to overestimate the BMC, and the curve fit for LDH in BALF is considered to be acceptable. LDH in BALF as reported in Glaser et al. (1990) is considered to be an acceptable endpoint for development of an RfC for inhalation of hexavalent chromium particulates, and Malsch et al. (1994) used a reasonable approach for development of a BMC based on this endpoint.

The threefold uncertainty factor used to account for the subchronic study is insufficient for development of the RfC for inhalation of chromium particulates. Glaser et al. (1985) demonstrated that at the end of the 90-day exposure period, chromium was still accumulating in the lung tissue of the test animals, suggesting that lower long-term exposures might lead to accumulation of a critical concentration in the lung. Subchronic studies also may not adequately predict the presence of inflammatory effects from lower long-term exposures. The Agency has therefore determined that a 10-fold uncertainty factor accounting for the use of a subchronic study is more appropriate in this case for the development of the RfC for inhalation of chromium particulates.

Selection of a threefold uncertainty factor to account for the pharmacodynamic differences not accounted for by the RDDR, an additional 10-fold uncertainty factor to account for the less-than lifetime exposure in Glaser et al. (1990), and a 10-fold uncertainty factor to account for variation in the human population generates a total uncertainty factor of 300. Application of the total uncertainty factor of 300 and the RDDR of 2.1576 to the BMC generated by Malsch et al. (1994) based on LDH in BALF (Glaser et al., 1990) results in an RfC of 0.1 $\mu\text{g}/\text{m}^3$ for inhalation of hexavalent chromium particulates. The selected RfCs are 0.008 $\mu\text{g}/\text{m}^3$ for chromic acid mists and dissolved hexavalent chromium aerosols and 0.1 $\mu\text{g}/\text{m}^3$ for hexavalent chromium particulates.

5.3. CANCER ASSESSMENT

5.3.1. Summary

There are many epidemiologic studies demonstrating that hexavalent chromium (CrVI) is a potential human carcinogen, but few provide adequate exposure data for use in risk estimation. Mancuso (1975) provides limited but adequate information for this purpose, and Mancuso's data are used as the main database for estimating the carcinogenic potency of hexavalent chromium. Three foreign studies on ferrochromium plants were also considered for use in the potency calculations. From the quantitative risk assessment viewpoint, these studies are less adequate than the Mancuso study. For the Norwegian study (Langard et al., 1980), the exposure measurements were taken in 1975, while some workers could have been exposed to chromium as early as 1928, when the ambient dust levels were much higher than in later years. For the Swedish study (Axelsson et al., 1980), the chromium-exposed workers did not show a significant increase of lung cancer, and thus only the statistical upper bound of the response can be used in potency estimation. It is expected that the use of data from the Norwegian and Swedish studies would result in an overestimation of the true carcinogenic potency of hexavalent chromium. While a Russian study (Pokrovskaya and Shabynina, 1973) does not have the deficiencies of the other two foreign studies, the cohort in this study is not well defined and is not suitable for use in risk assessment.

Animal data from intratracheal studies were not used to estimate the carcinogenic potency of chromium by inhalation because there is limited pharmacokinetic information relating the distribution of chromium to lung tissues by inhalation and by intratracheal administration. This information is needed to reconcile the differences in dose distribution between these two exposure patterns. Furthermore, the physiological mechanism of dose distribution by intratracheal administration may depend (in a nonlinear fashion) on the dose levels used in the experiment, as evidenced by the observation that a single administration of sodium dichromate induced a carcinogenic response in Sprague-Dawley rats but failed to induce a response when the same weekly dose was given over 5 days (Steinhoff et al., 1983).

5.3.2. Dose-Response Data

The Mancuso (1975) study was based on a cohort of 332 white male workers who were employed in a chromate plant between 1931 (when the plant began to operate) and 1937, and who were followed to 1974. Mancuso reported lung cancer death rates by levels of exposure to soluble, insoluble, and total chromium concentrations. Because only lung cancer mortality for total chromium exposure was reported by age group, only the dose-response data for total chromium were used to estimate the carcinogenic potency of hexavalent chromium. The use of dose-response data for total chromium would result in an underestimation of the potency of hexavalent chromium. An additional uncertainty of the study was the assumption that the smoking habits of chromate workers were similar to those of the general white male population. This assumption may lead to an overestimation of the role of hexavalent chromium in lung cancer seen in the cohort.

Exposure information in the Mancuso study was derived from an industrial hygiene study of the plant conducted in 1949 (Bourne and Yee, 1950). In this study, TWAs of exposure to insoluble, soluble, and total chromium per cubic meter were calculated for each occupation and for each worker in every department. Using these data and company personnel records, Mancuso was able to calculate an estimate of exposure to soluble, insoluble, and total chromium by duration of exposure (in $\text{mg}/\text{m}^3/\text{years}$) for each member of the 1931-37 cohort. In 1949, after the industrial hygiene study had been conducted, the company initiated a comprehensive program designed to reduce employees' exposures and improve manufacturing efficiency. Until that time, however, the company had not undertaken any programs for the purpose of reducing employee exposure. It should be noted that Bourne and Yee (1950), who conducted the industrial hygiene survey in 1949, reported that "in order to meet price and quality competition, improvements in equipment and processes have been made periodically during the past 18 years, and it is the universal experience of industrial hygiene personnel that greater process efficiency is almost invariably associated with a more healthful working environment. Therefore, there seems little doubt that atmospheric contamination in the past was greater than in 1949." Nonetheless, no concerted effort was made to reduce employee exposure until late in 1949, and because this particular plant was a relatively modern one at the time of the survey, it is unlikely that improvements in efficiency over the period 1931 to 1949 would have reduced employee exposure to a great extent. Thus, Mancuso is considered to have utilized a reasonable approximation of what workers in the study cohort were exposed to during their entire working history. Exposure in the cohort may be slightly underestimated because of the likelihood that a greater proportion of the "total exposure" was contributed prior to 1949 than after 1949. The effects of underestimating the exposure concentration, as well as the effects of other uncertainties on the estimation of potency, are addressed in Section 6.

5.3.3. Dose Conversion

Table 3, which is taken from Mancuso (1975), presents age-specific lung cancer deaths, corresponding person-years, and range of exposures to total chromium. To estimate the lifetime cancer risk due to exposure to chromium, it is assumed that an exposure, D ($\text{mg}/\text{m}^3/\text{years}$), as presented in Table 3, is equivalent to the continuous exposure d ($\mu\text{g}/\text{m}^3$) calculated by

$$d = \frac{D}{fL_e} \times \frac{8}{24} \times \frac{240}{365} \times 10^3 \mu\text{g}/\text{m}^3$$

where L_e is the midrange in each age category, f is the fraction of time in age exposed, and $8/24$ and $240/365$ are the fractions of a day and year, respectively, that a worker spent at the plant. For instance, if $D = 8 \text{ mg}/\text{m}^3/\text{years}$, $L_e = 60$, and $f = 0.65$, then $d = 44.96 \mu\text{g}/\text{m}^3$. The assumption of $f = 0.65$ implies that the cohort exposure to chromium began at approximately age 20. The assumption is that the particular exposure pattern (unknown) leading to the cancer mortality rates as observed is equivalent to the continuous constant exposure starting from the age when exposure began. This assumption may or may not be realistic. However, it would be less realistic to make a different assumption concerning the exposure pattern when the exposure estimates provided in Mancuso (1975) were determined using the weighted average of the duration of exposure for each respective job the worker had.

Since the person-year in each category presented in Table 2 is very small, the exposure categories are combined as shown in Table 4 to increase statistical stability. The last column of Table 4 is given for the purpose of identifying which exposure categories in Table 2 are combined. The midrange of age and exposure concentration is used in Table 4. Data in this table are used to estimate the lifetime cancer risk due to chromium exposure.

5.3.4. Extrapolation Method

It has been widely recognized (e.g., Doll, 1971) that the age-specific incidence curve tends to be linear on doubly logarithmic graphs, or equivalently, the age-specific incidence follows the mathematical form:

$$I(T) = bT^{k-1}$$

where b and k are parameters that may be related to other factors such as dose, and T may be one of the following three cases:

1. T is age when cancer is observed,
2. T is the time from the first exposure to observed cancer, or
3. T is the time from exposure to cancer minus the minimum time for a cancer to be clinically recognized.

Table 4. Combined age-specific lung cancer death rates and total chromium exposure (in $\mu\text{g}/\text{m}^3$)

| Age | Concentration ($\mu\text{g}/\text{m}^3$) | Deaths | Person-years | Background rate ^b | Exposure range |
|-----|--|--------|--------------|------------------------------|----------------|
| 50 | 5.66 | 3 | 1,345 | 6.05×10^{-4} | ≤ 1.99 |
| 50 | 25.27 | 6 | 931 | 6.05×10^{-4} | 2.0-5.99 |
| 50 | 46.83 | 6 | 299 | 6.05×10^{-4} | 6.0-7.99 |
| 60 | 4.68 | 4 | 1,063 | 1.44×10^{-3} | ≤ 1.99 |
| 60 | 20.79 | 5 | 712 | 1.44×10^{-3} | 2.0-5.99 |
| 60 | 39.08 | 5 | 211 | 1.44×10^{-3} | 6.0-7.99 |
| 70 | 4.41 | 2 | 401 | 1.57×10^{-3} | ≤ 1.99 |
| 70 | 21.29 | 4 | 345 | 1.57×10^{-3} | 2.0-7.99 |

^aThe midrange of each exposure category in Table 2 is first converted to $\mu\text{g}/\text{m}^3$ by using $f = 0.65$ in the formula described in the section “data available for potency calculations.” The concentrations presented in this table are the averages of several exposure categories weighted by corresponding person-years.

^bBackground rate is estimated from 1964 U.S. Vital Statistics. The year 1964 is selected because it is estimated that a large proportion of lung cancer deaths occurred during that year.

This model has been shown to arise from the somatic mutation hypothesis of carcinogenesis (Armitage and Doll, 1954; Whittemore, 1978; Whittemore and Keller, 1978). It has also been shown to arise from the epigenetic hypothesis when the reversible cellular change is programmed to occur randomly (Watson, 1977). These authors and many others have used this model to interpret and/or estimate potency from human data.

Since the data that could be used for risk estimation are limited, a simple model that fits the data should be used. Therefore, the observed age-specific incidence is assumed to follow the model

$$I(t,d) = B(t) + h(t,d)$$

where $B(t)$ is the background rate at age t and $h(t,d) = Q(d) t^{k-1}$ with $Q(d) = q_1d + q_2d^2$, a function of dose d .

Once the parameters q_1 , q_2 , and k are estimated, the lifetime cancer risk associated with an exposure d by age t , taking into account the competing risk, can be calculated by

$$t \qquad \qquad \qquad s$$

$$P(t,d) = \int_0^t h(s,d) \exp \left\{ -\int_0^s h(y,d) dy + A(s) \right\} ds$$

where $\exp[-A(s)]$ is the probability of surviving to age s and $h(t,d) = I(t,d) - B(t)$ is the age-specific incidence after adjusting the background rate.

To estimate the parameters in $h(t,d)$ we assume, as is usually done, that the number of lung cancer deaths, X , at age t , follows the Poisson distribution with the expected value

$$E(X) = N \times [B + Q(d) t^{k-1}]$$

where N is the person-year associated with X , B is the background rate at age t , and $Q(d) = q_1 d + q_2 d^2$.

Using the BMDP computer program P3R and the theory relating the maximum likelihood and nonlinear least square estimation by Jennrich and Moore (1975), the parameters q_1 , q_2 , and k are estimated by the method of maximum likelihood as $q_1 = 1.11 \times 10^{-7}$, $q_2 = 1.84 \times 10^{-9}$, and $k = 2.915$; the corresponding standard deviations are respectively 7.8×10^{-7} , 1.2×10^{-8} , and 1.7.

Thus, the age-specific cancer death incidence at age t due to chromium exposure $d \mu\text{g}/\text{m}^3$ is given by

$$h(t,d) = Q(d) t^{1.915}$$

where

$$Q(d) = 1.11 \times 10^{-7} d + 1.84 \times 10^{-9} d^2$$

The model fits the data well, as can be seen from the goodness-of-fit statistic

$$\chi^2 = \sum (O-E)^2/E = 1.60$$

which has, asymptotically, a chi-square distribution with 5 degrees of freedom under the model specified. The observed and predicted values used in calculating χ^2 are (3, 2.5), (6, 7.2), (6, 5.1), (4, 3.1), (5, 6.7), (5, 4.1), (2, 1.4), and (4, 4.3).

Taking into account the competing risk, the lifetime probability of lung cancer death due to exposure to chromium $d \mu\text{g}/\text{m}^3$ is given by

$$P(L,d) = \int_0^L h(t,d) \exp \left\{ -\left[\frac{Q(d)}{2.915} t^{2.915} + A(t) \right] \right\} dt$$

where L is the maximum human lifetime and is mathematically equivalent to infinity, since the probability of surviving beyond L is 0. At low doses approximately,

$$P(L,d) = d \times P(L,1)$$

where $P(L,1)$ is the lifetime cancer risk due to exposure to $1 \mu\text{g}/\text{m}^3$ of chromium. The unit risk, $P(L,1)$, has been adopted by the EPA as an indicator of the carcinogenic potency of a chemical compound.

5.3.5. Inhalation Unit Risk

To calculate the unit risk, $P(L,1)$ it is necessary to know $\exp[-A(t)]$, the probability of surviving to age t . Since this probability can only be estimated, it is assumed that the survival probability is constant over a 5-year interval, as provided in the U.S. Vital Statistics.

Using this approximation and by integrating the formula $P(L,1)$ we have

$$\begin{aligned} P(L,1) &= \sum [\exp(-3.87 \times 10^{-8} t_{i-1}^{2.915}) - \exp(-3.87 \times 10^{-8} t_i^{2.915})] \times P_i \\ &= 1.16 \times 10^{-2}/\mu\text{g}/\text{m}^3 \end{aligned}$$

where (t_{i-1}, t_i) is a 5-year interval and P_i is the probability of survival up to the age t_{i-1} . P_i is assumed to be a constant over the interval and is estimated from the 1975 U.S. Vital Statistics.

As a crude approximation, the carcinogenic potency of chromium can be also be calculated by $B = (R-1) \times P_o/d$, where $P_o = 0.036$ is the estimated lung cancer mortality rate for the U.S. population, R is the relative risk of the lung cancer deaths in the cohort, and d is the “standardized” lifetime dose concentration to which the workers were assumed to be exposed. This approach is used by EPA to calculate carcinogenic potency when the only data available are the relative risk estimate and an average exposure concentration.

For the Mancuso (1975) data, the relative risk R and the “standardized” dose d are estimated respectively to be $R = 7.2$ and $d = 15.5 \mu\text{g}/\text{m}^3$. They are calculated by combining the relative risks and dose concentrations in each of the age-exposure categories, weighted by the relative magnitude of person-years, as shown in Table 4.

Therefore, the carcinogenic potency of hexavalent chromium (CrVI) is estimated to be

$$B = (7.2-1) \times 0.036/15.5 = 1.4 \times 10^{-2}/\mu\text{g}/\text{m}^3$$

This crude estimate is only slightly higher than the previous estimate, $1.2 \times 10^{-2}/\mu\text{g}/\text{m}^3$.

6. MAJOR CONCLUSIONS IN THE CHARACTERIZATION OF HAZARD AND DOSE RESPONSE

6.1. HUMAN HAZARD POTENTIAL

Chromium is a naturally occurring element present in rocks, soils, plants, animals, and volcanic emissions. Chromium may exist in several chemical forms and valence states in the

environment. The most commonly occurring valence states are chromium metal (0), trivalent Cr(III), and hexavalent Cr(VI). The primary sources of hexavalent chromium in the environment are most likely chromate chemicals used as rust inhibitors in cooling towers and emitted as mists, particulate matter emitted during manufacture and use of metal chromates, and chromic acid mist from the chromeplating industry. Hexavalent chromium in the atmosphere may react with dust particles or other pollutants to form trivalent chromium, or may be removed from air by atmospheric fallout and precipitation. Hexavalent chromium may exist in aquatic media as watersoluble complex anions and may persist in water. Hexavalent chromium may also react with organic matter or other reducing agents to form trivalent chromium. Hexavalent chromium in soil tends to be reduced to trivalent chromium by organic matter.

Cr(III) potentiates the action of insulin in peripheral tissue and is essential for animals and human beings. Adults in the United States are estimated to ingest approximately 60 µg/day of chromium from food (ATSDR, 1993). The national Research Council has identified an estimated safe and adequate daily dietary intake (ESADDI) for chromium of 50-200 µg/d (NRC, 1989), corresponding to 0.71-2.9 µg/kg/day for a 70 kg adult. FDA has selected a Reference Daily Intake for chromium of 120 µg/d (DHHS, 1995).

The bioavailability of chromium may be the single most important factor determining the toxicity of a specific chromium source (O'Flaherty, 1996). Ingested hexavalent chromium is efficiently reduced to the trivalent form in the gastrointestinal tract. Gastrointestinal absorption of Cr(VI) occurs with greater efficiency than absorption of Cr(III), though absorption of ingested hexavalent chromium is estimated to be less than 5%. Following inhalation exposure, chromium may be absorbed into the systemic circulation, transferred to the gastrointestinal tract by mucociliary action, or remain in the lung. A number of factors can influence the absorption of chromium following inhalation, including the size, oxidation state, and solubility of the chromium particles; the activity of alveolar macrophages; and the interaction of chromium with biomolecules following deposition in the lung. Inhaled hexavalent chromium can be reduced to the trivalent form by ascorbate and glutathione. Absorption of inhaled chromium following occupational exposure has been demonstrated by the measurement of chromium in the serum and urine and hair of workers in the chromium industry. Water-soluble hexavalent chromium has been shown to be absorbed rapidly by inhalation in rats.

A significant amount of absorbed chromium is taken up in the bone, liver, kidney, and spleen. Hexavalent chromium readily crosses cell membranes through the phosphate and sulfate anion-exchange carrier pathway. Cr(III) compounds may cross cell membranes, but only with very low efficiency. Cr(VI) readily passes through cell membranes and produces a number of potentially mutagenic DNA lesions upon intracellular reduction to Cr(III). Hexavalent chromium is mutagenic in bacterial assays, yeasts, and V79 cells, and transforms both primary cells and cell lines.

Results of occupational epidemiologic studies of chromium-exposed workers across investigators and study populations consistently demonstrate that chromium is carcinogenic by the inhalation route of exposure. While data from these studies could be used to suggest that total chromium is carcinogenic by inhalation, animal data support the human carcinogenicity data

only on hexavalent chromium. Hexavalent chromium compounds have been shown to produce the following tumor types in animal assays: intramuscular injection site tumors in rats and mice, intrapleural implant site tumors in rats, intrabronchial implantation site tumors in rats, and subcutaneous injection site sarcomas in rats. Workers are exposed to both Cr(III) and Cr(VI) compounds. Because only Cr(VI) has been found to be carcinogenic in animal studies, however, it was concluded that only Cr(VI) should be classified as a human carcinogen.

At present, the carcinogenicity of hexavalent chromium by the oral route of exposure cannot be determined because of a lack of sufficient epidemiological or toxicological data. One study of miners in Ontario suggested that exposure to chromium may have been associated with stomach cancer, but other human and animal studies have not reported similar effects.

A number of epidemiological studies of workers in chromium production facilities have demonstrated an association between inhalation of Cr(VI) and upper respiratory irritation and atrophy, lower respiratory effects, and renal effects. There is significant uncertainty regarding the relevance of occupational exposures to chromic acid mists to environmental exposures to hexavalent chromium particulates, as well as the role of direct contact between chromium-contaminated hands and nasal passages in the studies reporting nasal irritation, atrophy, and nasal septum perforation in the occupational setting. Animal studies have reported a variety of effects including perforation of the nasal septum, necrosis, atrophy and hyperplasia of the bronchial epithelium, bronchiolization of the alveoli, alveolar proteinosis, changes in lung weight, lactate dehydrogenase in BALF, albumin in BALF, changes in tracheal and submandibular lymph nodes, atrophy of the spleen and liver, and ulcerations in the stomach and intestinal mucosa following exposures to Cr(VI) compounds by inhalation (Steffee and Baetjer, 1965; Nettesheim et al., 1971; Glaser et al., 1985; Glaser et al., 1990).

Little data exist regarding health effects resulting from ingestion of hexavalent chromium. A single cross-sectional study was located that reported effects in humans resulting from ingestion of chromium-contaminated well water. Residents of a village in China were reported to have experienced oral ulcers, diarrhea, abdominal pain, indigestion, vomiting, leukocytosis, and presence of immature neutrophils. Other reports of toxic effects of Cr(VI) in humans are limited to case reports from accidental poisonings. With the exception of increased body burden of chromium, no significant adverse effects have been observed in animal studies following ingestion of chromium.

High oral doses of hexavalent chromium compounds have been reported to cause reproductive and developmental toxicity in mice, including decreased fetal weight, increased resorptions, and increased abnormalities. A recent study in mice and rats determined that hexavalent chromium is not a reproductive toxicant in either sex.

Chromium is one of the most common contact sensitizers in industrialized countries, and allergic contact dermatitis is associated with occupational exposures to numerous materials and processes, including chromeplating baths, chrome colors and dyes, cement, tanning agents, and wood preservatives.

6.2. DOSE RESPONSE

The data of Mancuso (1975) were used to generate the unit risk for inhalation of hexavalent chromium of $1.2 \times 10^{-2}/\mu\text{g}/\text{m}^3$. A recent follow-up study (Mancuso, 1997) is supportive of the conclusions of Mancuso (1975); however, several important uncertainties in the potency estimate result from the use of the Mancuso data for the dose-response estimation.

The risk of hexavalent chromium is estimated on the basis of the total chromium obtained from all the soluble and insoluble chromium to which workers were exposed. Since there are likely differences between the chromium compounds to which workers were exposed, the potency of hexavalent chromium compounds may be underestimated. Bourne and Yee (1950) reported that the ratios of Cr(III) to Cr(VI) concentrations in the airborne dust in nine major departments in the plant in which the Mancuso cohort worked ranged from 1 to 3, except for two departments where the ratios were 6 for the lime and ash operation and 52 for the ore preparation. Excluding the ore operation, the maximum ratio of trivalent chromium to hexavalent chromium is 6, and thus the underestimation of the risk for hexavalent chromium is unlikely to be greater than sevenfold.

Use of the hygiene data collected in 1949 may result in a slight underestimation of the levels of exposure workers experienced between 1931 and 1937. However, because the plant was relatively modern in the 1930s, the underestimation is unlikely to be large. If an underestimation of 2 times were assumed, then the unit risk would be reduced from $1.2 \times 10^{-2}/\mu\text{g}/\text{m}^3$ to $6 \times 10^{-3}/\mu\text{g}/\text{m}^3$.

The risk presented in this report may be somewhat overestimated as a result of the assumption that smoking habits of chromate workers were similar to those of the general white male population. It is generally accepted that the proportion of smokers is higher for industrial workers (thus the higher background incidence rates) than for the general population. For example, the background age-specific rate of lung cancer at ages 50, 60, and 70 could be 40% greater than that presented in Table 4 should it be assumed that 80% of the chromate workers in the Mancuso study were ever-smokers (individuals who smoke at least 100 cigarettes during their lifetimes) and only 50% of the general white male population were ever-smokers. For example, if the background rate of lung cancer mortality (due to smoking) for the cohort in Table 4 is increased by 40%, then the corresponding unit risk would be reduced by about 25%, or from $1.2 \times 10^{-2}/\mu\text{g}/\text{m}^3$ to $8.7 \times 10^{-3}/\mu\text{g}/\text{m}^3$.

Relatively few studies in the literature address the oral toxicity of Cr(VI). The Zhang and Li (1987) human study reported on health effects in 155 Chinese villagers who consumed drinking water contaminated with hexavalent chromium at 20 ppm. Only one exposure level was included and the study did not indicate whether the drinking water was contaminated with other materials in addition to hexavalent chromium. The study also did not address whether potential airborne exposures to hexavalent chromium from the plant or other confounding factors may have contributed to observed effects. The exposure period was unknown, and the study could not provide a NOAEL for the observed effects. However, the study of Zhang and Li suggests that

gastrointestinal effects in humans may occur at an exposure level of 20 ppm of hexavalent chromium in drinking water.

Two studies have reported fetotoxic and developmental effects of Cr(VI) in mice and rats at exposure levels of 250 - 700 ppm in drinking water (Junaid et al., 1996; Kanojia et al., 1996). While neither of these studies provide clear NOAEL values, LOAELs for fetotoxicity can be used to extrapolate to NOAELs of 6.7 mg/kg-day and 3.7 mg/kg-day in mice and rats, respectively.

Both the MacKenzie et al. (1958) and Anwar et al. (1961) animal studies are limited by a small number of animals/group and a lack of an observed effect at any dose level. The MacKenzie et al. study has the additional limitation of being conducted for less than a lifetime. However, the MacKenzie study was considered to be most suitable for the dose-response assessment for ingested chromium and generated an adjusted NOAEL of 2.5 mg/kg-day.

The adjusted NOAEL from the MacKenzie study was modified by two 10-fold uncertainty factors to account for the expected interspecies and interhuman variability in lieu of specific data. An additional threefold uncertainty factor is applied to the adjusted NOAEL to compensate for the less-than-lifetime exposure duration in the Mackenzie study. A modifying factor of 3 is applied to account for uncertainties resulting from study of Zhang and Li. The total uncertainty factor applied to the adjusted NOAEL is 900, yielding an RfD of 3×10^{-3} mg/kg-day. Confidence in the oral reference dose is low. Confidence in the chosen study is low because of the small number of animals tested, the small number of parameters measured, and the lack of toxic effect at the highest dose tested. Confidence in the database is low because the supporting studies are of equally low quality, because of concerns raised by the study of Zhang and Li, and because of the lack of information on teratogenic endpoints. Low confidence in the RfD follows.

Two RfCs have been generated for hexavalent chromium. The RfC for chromic acid mists and dissolved hexavalent chromium aerosols is based on a study of workers in a chromium plating facility (Lindberg and Hedenstierna, 1983). The occurrence of nasal mucosal atrophy in the Lindberg and Hedenstierna study is consistent with previous reports that exposure to chromium acid mists is associated with ulceration of the mucous membranes and perforation of the cartilaginous portions of the nasal septum (Hamilton and Hardy, 1974).

Several uncertainties result from the exposure characterization in the Lindberg and Hedenstierna (1983) study. While nasal mucosal atrophy has been consistently reported following occupational exposure to chromic acid mists, it is uncertain whether these exposures are relevant to exposures to hexavalent chromium particulates in the environment. The LOAEL for this study is based on an 8-hour TWA concentration. However, it is possible that the exposure response may be better explained by the peak exposure rather than the TWA dose. The authors acknowledge that nasal septum ulcerations and perforations did not correlate with mean exposure concentrations in the 2-20 $\mu\text{g}/\text{m}^3$ group and observed that damage to the nasal septum correlated better with short-term peak exposure than with 8-hour mean exposures. The report does not provide sufficient detail on peak exposures to resolve this issue unequivocally, and in the absence of additional data, the RfC was generated based on the TWA exposure. The RfC

based on Lindberg and Hedenstierna (1983) is applicable only to chromic acid mists and dissolved hexavalent chromium aerosols.

Confidence in the RfC for chromic acid mists and dissolved hexavalent chromium aerosols is low. Confidence in the chosen study is low because uncertainties regarding the exposure characterization and the role of direct contact for the critical effect. Confidence in the database is low because the supporting studies are equally uncertain with regard to the exposure characterization. Low confidence in the RfC follows.

The RfC for hexavalent chromium particulates was developed based on Glaser et al. (1985, 1990). Several uncertainties are associated with the use of these studies for development of the RfC. Glaser et al. (1985, 1990) did not provide details of upper respiratory, reproductive, or renal effects resulting from the exposures, and did not include chromic acid mists or dissolved hexavalent chromium aerosols in their study. This uncertainty has been addressed by limiting the RfC developed on the basis of Glaser et al. (1985, 1990) to lower respiratory effects from inhalation of hexavalent chromium dusts. Uncertainty results from the use of a subchronic study for development of the chronic RfC. This uncertainty was addressed by the use of a 10-fold uncertainty factor to account for potential chronic effects. It is uncertain which of the endpoints reported in Glaser et al. (1985, 1990) is most appropriate for development of the BMC. LDH in BALF was used for development of the RfC, as this endpoint is considered to be a sensitive indicator of toxicity and provides the most conservative estimate of the BMC based on the Glaser et al. (1985, 1990) data. Uncertainty in the dose-response curve for LDH in BALF was addressed through the use of a conservative model fit of the data.

Confidence in the RfC for hexavalent chromium particulates is medium. Confidence in the chosen study is medium because of uncertainties regarding upper respiratory, reproductive, and renal effects resulting from the exposures. Medium confidence in the RfC follows.

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APPENDIX A. EXTERNAL PEER REVIEW— SUMMARY OF COMMENTS AND DISPOSITION

The support document and IRIS summary for hexavalent chromium have undergone both internal peer review performed by scientists within EPA and a more formal external peer review performed by scientists performed accordance with EPA guidance on peer review (U.S. EPA, 1992). Comments made by the internal reviewers were addressed prior to submitting the documents for external peer review and are not part of this appendix. The external peer reviewers were tasked with providing written answers to general questions on the overall assessment and on chemical-specific questions in areas of scientific controversy or uncertainty. A summary of significant comments made by the external reviewers and EPA's response to these comments follows.

Comments on General Questions for IRIS Peer Reviewers

1. *Are you aware of any other data/studies that are relevant (i.e., useful for the hazard identification or dose-response assessment) for the assessment of the adverse health effects, both cancer and noncancer, of this chemical?*

A. Comment: Since Mancuso has recently updated his cohort and since the information is already referenced in the IRIS and the Toxicological Review document, I believe the cancer slope factors should be recalculated from the total chromium data and the Cr(VI) data.

Response to Comment: The Agency agrees that the cancer slope factor should be recalculated from the updated cohort. The Agency is unable to do so in a time frame consistent with the IRIS Pilot process, and will take up revision of the slope factor when possible.

B. Comment: In calculating the oral reference dose the authors used data from a rodent study by MacKenzie et al. (1958) and discounted data from a human study by Zhang et al. I am concerned that the NOAEL in the animal study exceeded the level reported in the Chinese study (20 ppm) that caused serious illness in humans.

Response to Comment: The study of Zhang and Li (1987) raises concerns for human gastrointestinal effects at high dose levels in drinking water; however, the exposure data in this study are limited, the duration of exposure is unknown, the presence of confounding factors is not addressed, and a NOAEL could not be identified from the study. While these uncertainties preclude the use of this study for risk assessment, a threefold modifying factor has been applied to the NOAEL derived from the study of MacKenzie et al. (1958) to address the concerns raised by the study of Zhang and Li (1987).

C. Comment: Several new reports have been found showing significant embryotoxic and fetotoxic damage due to exposure of rats and mice to high doses of Cr(VI) or Cr(III) in drinking water. I don't feel confident rederiving an RfD based on this data, and the doses are clearly very high. However, derivation of an RfD based on an observed toxicological effect appears to be preferable to an RfD based on a NOAEL.

Response to Comment: The reports have been added to the reproductive/developmental studies section of the toxicological review document and have been considered in the development of the RfD for Cr(VI). The new reports do not provide a clear NOAEL for the fetotoxic and embryotoxic effects. Extrapolated LOAELs derived from the studies of Junaid et al. (1996) and Kanojia et al. (1996) are similar to and support the use of the NOAEL identified in the study of MacKenzie et al. (1958) for development of the RfD.

D. Comment: The documents correctly state that Cr(VI) gets transformed to Cr(III) in vivo, but they skirt the issue of whether or not a Cr(VI) study is really a study of in vivo exposure to Cr(III).

Response to Comment: Given the rapid reduction of Cr(VI) to Cr(III) in vivo, it is relevant to consider whether environmental exposures to Cr(VI) or administration of Cr(VI) in controlled animal experiments is essentially identical to environmental exposures to Cr(III) or administration of Cr(III) in controlled experiments. While considerably more data are available for Cr(VI) than for Cr(III), it appears at present that exposures to Cr(VI) have considerably different outcomes than exposures to Cr(III). The Agency has prepared the toxicological summaries and IRIS files for Cr(VI) and Cr(III) from this perspective.

2. *For the RfD and RfC, has the most appropriate critical effect been chosen (i.e., that adverse effect appearing first in a dose-response continuum)? For the cancer assessment, are the tumors observed biologically significant? Relevant to human health? Points relevant to this determination include whether or not the choice follows from the dose-response assessment, whether the effect is considered adverse, and if the effect (including tumors observed in the cancer assessment) and the species in which it is observed is a valid model for humans.*

A. Comment: The descriptions of the study used to develop the RfC for chromic acid mist were confusing. While I agree that the LOAEL is 0.002 mg/m^3 , I question the uncertainty factor of 3 to extrapolate from subchronic to chronic exposure. Virtually all the workers in the high dose level in the Lindberg cohort had significant effects even though the duration of exposure for workers with nasal ulcerations ranged from 5 mo to more than 10 years.

Response to Comment: The descriptions of the study of Lindberg and Hedenstierna (1983) have been improved. The experience of workers at the high dose level with significant effects over a subchronic exposure period does not eliminate the possibility that similar effects could occur at considerably lower doses over a chronic exposure period. In order to account for this uncertainty, the Agency favors use of a threefold factor to extrapolate from the subchronic to chronic exposures.

B. Comment: The authors argue that the threefold uncertainty factor used by Malsch et al. is insufficient. I disagree. In the Glasser paper the concentration in the lung appears to be approaching a maximum at 90 days. The authors also suggest that inflammatory effects from lower long-term exposures may occur. In my experience inflammation is an early symptom and

in some cases even regresses in the presence of continuing exposure. Thus, I would use Malsch's calculations as published yielding a RfC of 0.34 mg/m³.

Response to Comment: Information from Glaser (1985) shows that chromium is still accumulating in the lung and kidney at the end of the 90-day exposure period and there is insufficient information to determine how well subchronic studies predict chronic inflammation. The Agency supports the use of a 10-fold uncertainty factor to extrapolate from a subchronic to a chronic study.

C. Comment: The additional uncertainty factor of 3 (for the RfD) to compensate for less than lifetime exposure duration in the MacKenzie et al. study can be questioned. Why not apply a 10-fold uncertainty factor for this purpose, based also on the relatively low number of animals used in the study?

Response to Comment: The use of the MacKenzie et al. study for development of the RfD is considered to be conservative, given the lack of an observed effect in the animals. Even in light of the relatively low number of animals in the study, the threefold uncertainty factor is considered by the Agency to be sufficient for development of the RfD.

3. *Have the noncancer and cancer assessments been based on the most appropriate studies? These studies should present the critical effect/cancer (tumors or appropriate precursor) in the clearest dose-response relationship. If not, what other study (or studies) should be chosen and why?*

A. Comment: A level of 0.002 mg/m³ in the Lindberg and Hedenstierna study was chosen as the LOAEL for the RfC. This level caused significant symptoms, including atrophied nasal mucosa, in workers exposed, whereas no symptoms were seen at a level of 0.001 mg/m³. Therefore, why not use this lower level as a NOAEL?

Response to Comment: Although no subjective irritation occurred in the subgroup exposed at 0.001 mg/m³, the distribution of the four cases of atrophy in this group was not provided, which precluded designation of a NOAEL at 0.001 mg/m³.

B. Comment: The RDDR is based on aerodynamic diameters of particles used in the animal studies; however, it would be helpful to also know something about ambient particle sizes containing chromium such that a more appropriate dosimetric adjustment across species using differences in particle deposition between rodents and humans can be applied.

Response to Comment: Data on ambient particle sizes containing chromium are necessarily site specific, and will vary depending on the nature of the contaminated media and exposure setting. While it might be of interest to determine the ambient particle size distribution in order to develop a site-specific RDDR, these data cannot be practically incorporated into the RDDR in order to account for all of the possible ambient exposures. The assessment has utilized the data in the Agency's guidance for development of RfCs for this purpose.

C. Comment: It appears that the endpoint albumin in bronchoalveolar lavage fluid showed even greater effects than LDH, and I wonder why this endpoint was not selected for the benchmark approach.

Response to Comment: LDH in BALF provided a BMD approximately one-half that of albumin in BALF (Malsch et al., 1994). In order to be conservative and focus on the critical effect, LDH in BALF was chosen as the endpoint for development of the RfC.

D. Comment: The fact that chromium was still accumulating in lung tissue at the end of a 90-day exposure does not suggest that lower long-term exposures will lead to accumulation of a critical concentration in the lung. This depends very much on the clearance kinetics, and at low concentrations lung levels will reach an equilibrium that is lower than that achieved at higher concentrations.

Response to Comment: The Agency acknowledges the possibility that at low concentrations lung levels will reach an equilibrium which is lower than that achieved at higher concentrations. However, in the absence of data, it cannot be demonstrated that chronic exposures will not lead to accumulation of a critical concentration in the lung. In order to conservatively reflect the uncertainty on this issue, the Agency has utilized a 10-fold uncertainty factor to account for less-than lifetime exposure.

4. *Studies included in the RfD and RfC under the heading “Supporting/Additional studies” are meant to lend scientific justification for the designation of critical effect by including any relevant pathogenesis in humans, any applicable mechanistic information, any evidence corroborative of the critical effect, or to establish the comprehensiveness of the database with respect to various endpoints (such as reproductive/developmental toxicity studies). Should other studies be included under the “Supporting/Additional” category? Should some studies be removed?*

A. Comment: The new data on reproductive toxicity of chromium in the drinking water needs to be carefully compared to the NTP study in which rats and mice were fed potassium chromate in the diet. The form of chromium and route of exposure are clearly of paramount importance.

Response to Comment: A discussion comparing and contrasting the results of the NTP studies and the new reports has been added to the reproductive/developmental studies section of the toxicological review document.

B. Comment: Some of the statements related to the genotoxic effects of hexavalent chromium are either inaccurate or misleading.

Response to Comment: The recommended modifications to this section have been made.

5. *For the noncancer assessments, are there other data that should be considered in developing the uncertainty factors of the modifying factor? Do you consider that the data support the use of different (default) values than those proposed?*

A. Comment: No comment received.

6. *Do the confidence statements and weight-of-evidence statements present a clear rationale and accurately reflect the utility of the studies chosen, the relevancy of the effects (cancer and non-cancer) to humans, and the comprehensiveness of the database? Do these statements make sufficiently apparent all the underlying assumptions and limitations of these assessments? If not, what needs to be added?*

A. Comment: Yes.

Comments on Chemical-Specific Questions

1. *Are the conclusions of Zahid et al. regarding potential reproductive toxicity of Cr(III) in any way countered by the results of the NTP study?*

A. Comment: The Cr(VI) document does a superficial job of communicating the deficiencies of the Zahid study.

Response to Comment: Additional information has been provided in the reproductive/developmental effects section to address this concern.

2. *Should separate RfCs be generated for chromic acid mists and particulates of hexavalent chromium?*

A. Comment: Yes.

B. Comment: Yes, the bioavailability and physiological effects of these two forms of chromium appear to differ substantially.

Response to Comments: Separate RfCs have been generated for chromic acid mists and particulates of hexavalent chromium.

3. *Should the RfCs apply to both Cr(VI) and Cr(III) or only to Cr(VI)?*

A. Comment: The RfCs based on data from Lindberg and Hedenstierna and Glaser are appropriate only for Cr(VI).

4. *Are there any studies available that could be used to develop an RfC for trivalent chromium?*

A. Comment: The Agency has determined that an RfC for Cr(III) cannot be developed and I agree.

5. *The principal study (Mancuso, 1975) and the follow-up study (Mancuso, 1997) show the best dose-response relationship for total chromium, but animal data support a conclusion of carcinogenicity only for hexavalent chromium. Should the potency estimate address total chromium or hexavalent chromium?*

A. Comment: The potency estimate should be based on total chromium, but should note that the exposure is mixed.

Response to Comments: EPA will reevaluate the potency estimate for chromium based on the recent Mancuso update in the future.

B. Comment: The potency estimates should be based on hexavalent chromium.

Response to Comment: EPA will re-evaluate the potency estimate for chromium based on the recent Mancuso update in the future.

6. *There is a Canadian study that relates stomach cancer to gold mining following exposures to chromium. Does this study justify/support determination of an oral factor for chromium?*

A. Comment: I believe the Canadian study should not be used to determine an oral slope factor.

Response to Comment: The Canadian study has not been used to determine an oral slope factor.

NEIC

EPA-331/9-99-001

**MULTIMEDIA COMPLIANCE MONITORING
INVESTIGATION PROTOCOL FOR THE
SHIP SCRAPPING INDUSTRY**

February 1999

National Enforcement Investigations Center, Denver

U.S. Environmental Protection Agency



Office of Enforcement

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF ENFORCEMENT AND COMPLIANCE ASSURANCE

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Larry Strattan

NATIONAL ENFORCEMENT INVESTIGATIONS CENTER
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INTRODUCTION

PURPOSE AND SCOPE OF THIS MANUAL

At the request of the EPA Office of Enforcement and Compliance Assurance, the National Enforcement Investigations Center (NEIC) has compiled a multimedia compliance monitoring investigation protocol for the ship scrapping industry. This protocol is intended as a guide for investigators who conduct multimedia environmental compliance investigations of ship scrapping facilities that discharge, emit, prepare, manage, store, or dispose of pollutants regulated by federal, state, or local environmental statutes and requirements. Investigative methods are presented that integrate enforcement program requirements for air, water, solid waste, pesticides, and toxic substances. This manual describes general activities and functions of multimedia investigations, provides information on special features of specific media and associated statutes, and contains an overview of the ship scrapping industry. This manual is intended to supplement the various media-specific investigation guides listed in the reference section and any regional, state, or local guides not referenced.

Multimedia compliance investigations are intended to determine a facility's compliance status with applicable laws, regulations, and permits. Appendix A contains a source list of summaries for applicable environmental laws which EPA administers and enforces. Inspection emphasis should be identifying violations of regulations, permits, approvals, orders, and consent decrees, and the underlying causes of such violations. Investigators should thoroughly identify and document violations and problems that have existing or potential effect on human health and/or the environment as well as others.

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Multimedia investigations are conducted as a series of tasks or phases, which usually include:

- Determination of target facility/project request
- Identification of specific objectives
- Project team formation
- Background information review
- Project plan preparation
- On-site field inspection
- Report preparation
- Enforcement case support (varies and will not be addressed in this manual)

These phases are discussed in detail in the revised March 1992 "NEIC Multimedia Investigation Manual" [Appendix A]. The protocol advocates a multimedia approach, but individual media inspections can always be conducted at different times.¹

All investigations should result in the generation of a written report that documents noncompliance or other areas of concern identified during the investigation. Areas of concern are inspection observations of potential problems that could result in environmental harm, noncompliance with permit or regulatory requirements, or are areas associated with pollution prevention issues. This manual identifies multimedia objectives and focuses on specific

¹ *The protocol in this ship scrapping manual has been developed from inspections of three ship scrapping facilities located at the Port of Brownsville, Texas. This draft protocol was reviewed by EPA Regional offices that cover geographic areas where shipbreaking may occur, for input to present a more comprehensive perspective on the industry.*

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environmental laws and associated statutes applicable to the ship scrapping industry.

Ship scrapping operations are of environmental concern because they are regulated by a number of statutes, and generate large amounts of waste, including asbestos and PCBs. Investigations of ship scrapping facilities are similar to other comprehensive multimedia compliance monitoring investigations, and typical objectives would be to determine compliance with the following:

- Air pollution control regulations including National Emission Standards for Hazardous Air Pollutants (NESHAP)
- Water pollution control regulations, including National Pollution Discharge Elimination System (NPDES) permit requirements, pretreatment requirements, storm water requirements, and Spill Prevention Control and Countermeasures (SPCC) regulations
- Safe Drinking Water Act, including Underground Injection Control and Public Water Supply
- Solid and hazardous waste management regulations, including Land Disposal Restrictions (LDR)
- Underground Storage Tank (UST) regulations
- Toxic Substances Control Act (TSCA) regulations
- Emergency Planning and Community Right-to-Know Act (EPCRA) and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) § 103

OVERVIEW OF THE SHIP SCRAPPING INDUSTRY

Ship scrapping is the process of dismantling ships for recovery of scrap steel, copper, and other metals. The standard industrial code (SIC) for ship scrapping is 4499 (ship dismantling or shipbreaking). Although shipbreaking can be done at a shipyard, it is more often conducted at less developed facilities. For example, the shipbreaking process on the Gulf Coast at Brownsville, Texas is performed with minimal investment in infrastructure. All the sites have slips where most of the shipbreaking is performed. The slips are excavated inward from the ship channel. The slips are generally 400 to 700 feet long, and 100 to 120 feet wide at the slip entrance from the ship channel, and are of soil construction. The slips are dredged openings in the bank of the ship channel and decrease in depth going away from the ship channel. A large winch at the head of the slip is used to beach/ground the vessel and drag the hull farther and farther into the slip as work progresses.

The three Gulf Coast ship scrappers have minimal on-shore support facilities, a few buildings, trailers, and tanks. Shipyards, where ship building and repair occurs, are much different from ship scrapping operations. For example, Portsmouth Naval Shipyard, Kittery, Maine; Philadelphia Naval Shipyard, Philadelphia, Pennsylvania; and Norfolk Naval Shipyard, Norfolk, Virginia all have extensive shore facilities to support ship building and repair activities. There are numerous shops for the technical trades and many highly skilled workers. In contrast, ship scrappers hire mostly unskilled or semi-skilled workers with minimal training. In some ship scrapping facilities, the workers are likely to be non-English speaking with bilingual supervisors.

Inspection teams should be aware of potential language barriers in questioning workers.

Ship scrapping can be conducted by different methods, but the Gulf Coast ship scrapping operations observed in Brownsville initiated the process with the ship moored, not beached. After mooring the vessel, the ship scrappers must locate or prepare a ship's diagram of all rooms, compartments, tanks, and storage areas. Although the Navy should provide these diagrams for its ships, some of the older "mothballed" vessels are received for scrapping without diagrams. Areas which may contain hazardous materials such as fuels, oils, asbestos, PCBs, and hazardous waste are reportedly identified. Fuels and oils are pumped out of the onboard tanks and transported to reclaimers. Then, a marine chemist (the marine equivalent of an industrial hygienist) is contracted to certify that the ship is fuel-free, permitting the issuance of hot work permits. Hot work permits allow cutting torches and saws to be used to dismantle the ship. The hot work permits do not deal with environmental concerns such as cutting through lead or PCBs present on painted surfaces. The Coast Guard requires floating booms be placed around the moored vessels to contain any spills.

Bilge and ballast water may be removed from the vessel when fuels are removed or later. Oily water and fire control water also accumulates during the ship scrapping process. These waste waters may be sent off-site for treatment and disposal or treated on-site.

The Brownsville facilities that NEIC inspected all had large liquid oxygen tanks with vaporization radiators connected to underground piping to provide

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oxygen for the cutting torches. The fuel, either natural gas or propane, was also supplied by underground piping extending to the edge of the slip. Material is removed from vessels by either collecting segregated smaller items in containers placed on the deck, or by cutting room-sized pieces from the vessel and removing them by mobile, track-mounted cranes. The large pieces are placed on the shore to be cut into smaller pieces appropriate for shipment as scrap metal (smaller than 2 or 3 feet by 5 feet for steel plate). The area parallel to the slip on each side is kept clear for the crane or vehicles. Pieces are cut from the vessel starting at the bow and the top, resulting in a diagonal plane of progression toward the stern of the vessel.

Sampling to detect the presence of polychlorinated biphenyls (PCBs) and asbestos is usually performed one deck at a time. On each deck, work proceeds from bow to stern. Necessary removals are performed shortly before the actual cutting of the ship occurs. First, attached non-metal wall coverings, dividers, and other items to be landfilled would be collected into containers on the open deck. Remaining accessible PCB-containing electrical cables would also be removed at this time and placed into a separate container on deck; some cable may be left in place on the room-sized pieces to be removed after the large piece is removed to shore. Asbestos removals are also often done just ahead of the cutting operation, but before PCB removals. After accessible asbestos and PCB items are removed, smaller items are removed such as gauges and other salable items. Finally room-sized pieces are cut and lowered to shore by crane. As they become accessible, remaining PCB-containing electrical cables are removed from the room-sized pieces in the yard.

Asbestos remediation is conducted to allow asbestos-free sections of the ship to be cut off in large sections and lifted to the ground by crane. Engine rooms usually contain more asbestos containing material than other areas of the ship, and thus, take the longest to remediate. As asbestos-free sections of the ship are removed, the engine rooms are left intact until asbestos remediation there is complete.

After the ship has been cut down to the lowest deck, it is winched to the head of the slip and portions of the bow are cut off. The ship is winched progressively farther ashore, until the scrapping is completed.

Further dismantling/cutting is done on the shore by cutting the steel into about 2- by 5-foot sections which can be loaded onto trucks or railcars. The workers at each facility primarily used hand held 6-foot long torches for cutting, although small cutting torches are sometimes used in tight spaces. The large torches help protect the worker from the fumes, sparks, and the danger of falling scrap.

One shipbreaker compared shipbreaking to a mining operation with 8 to 10% of the total ship tonnage not recyclable (i.e., asbestos, PCBs, hazardous waste, trash, etc.). Thus, a 10,000-ton ship would have about 800 to 1,000 tons of asbestos, PCBs, hazardous waste, trash, etc. The main "extractable" or recoverable material is steel/scrap metal cut into about 2- by 5-foot plates for shipment to steel mills by truck, rail, or barge. Copper is extracted from all the communications, electrical, demagnetizing, and miscellaneous cables. Other non-ferrous metals, such as brass and aluminum, are also extracted. Gauges, boilers, motors, and anything usable is sold, if possible, for re-use. According to

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shipbreaking industry representatives, although ship scrapping facilities look disorganized, segregation of extractables/recoverable materials (steel, copper, brass, aluminum, usable items) is conducted in a systematic fashion.

Solid wastes, air emissions, and wastewater streams are generated during ship scrapping operations. Major waste streams typical for selected ship scrapping operations are identified in Table 1 and are discussed in more detail in the appropriate media sections.

Table 1

MAJOR WASTE STREAMS/SOURCES

| Operations | Solid Waste | Air Sources | Wastewater Sources/Stream |
|---|--|--|---|
| Clean out vessel upon receipt at facility | Paint, cleaning solutions, miscellaneous chemicals | | |
| Empty vessel tanks | Sludges/tank bottoms, fuels, oils | Hydrocarbons from transfer operations | Bilge, ballast, and fresh water |
| Remediate asbestos | Asbestos-containing material | | Excess water from remediating migrates to lower decks |
| Remove PCB items | PCB waste | | |
| Cutting torches | Slag | Hydrocarbons, red lead, dibenzo furans, small fires from oil on bulkheads or decks | Water used to cool hot surfaces migrates to lower decks |
| Processing electrical cables | Fluff may contain asbestos and/or PCBs | | |
| Fire control | | Hydrocarbons | Water migrates to lower decks |
| Maintenance | Used oil | | |

Inspection team safety considerations are very important when conducting an inspection at any ship scrapping operation. By using adequate personnel protective clothing/safety gear, inspectors can ensure not only personal safety, but access to areas where wastes

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are located and/or being generated. Inspecting a ship scrapping facility requires team members to be alert to potential hazards. Deck surfaces and much of the on-shore work area surfaces are often not smooth, but littered with various objects. There are many cables, hoses, and other trip hazards. Unremediated areas of the ship may have loose asbestos insulation underfoot. Gang planks and ladders (stairs onboard ships are called, and more often resemble, ladders) may be steep and often require two hands and careful attention to overhead hazards to negotiate. The ship is being taken apart and the ship or ship fixtures may be loose, wet or oily, or hot. Areas of the vessel will be dark, or present other hazards. A flashlight or a miner's type lamp for hard hats is a necessity. A half-face respirator may provide better visibility to negotiate ladders in dimly lit areas. Cutting torches and associated toxic lead fumes, that may be generated when cutting steel plate coated with lead paint, should be given a wide berth. In order to more fully evaluate regulatory compliance, certain observations such as ongoing asbestos remediation would require personal protective equipment. Items such as tyvek-coated coveralls, respirator, gloves, hard hat, eye and hearing protection, and steel-toed safety shoes need to be available to members of the inspection team and addressed in a safety plan [Appendix B]. Inspectors must be aware of their surroundings at all times and never compromise their safety because of the dangerous activities at any ship scrapping operation.

INSPECTION CONSIDERATIONS

The time required to scrap a vessel is typically measured in months or years. An aircraft carrier may take 2 years, most large ships would take 3 to 9 months, and smaller vessels may be scrapped in a month or 2.

A large multimedia inspection team would not be appropriate for small facilities with limited environmental staff; a two- or three-person team would be more effective. (There was only one environmental person at each facility inspected in Brownsville.) If additional inspectors are needed to cover all the media, a four- to six-member team could inspect two facilities per week (or other time unit) using two teams of two to three inspectors each and switching facilities midweek (e.g., team A would spend the first half of the week at facility A and the second half of the week at facility B conducting media inspections for air, asbestos, and hazardous waste at each facility, while team B would spend the first half of the week at facility B and the second half of the week at facility A conducting media inspections for water, SPCC, and PCBs at each facility).

INSPECTION OBJECTIVES

Typical objectives for multimedia compliance monitoring inspections of ship scrapping facilities would be to determine compliance with the applicable regulations. All regulations may not be applicable at each facility and the objectives should be defined by inspection team members based on available background information. In addition, inspection personnel should identify activities/conditions that have an impact on, or could potentially impact, the environment, whether or not there are specific written requirements or standards.

INVESTIGATION METHODS

A typical investigation of a ship scrapping facility would probably include:

- A preinspection review of EPA and state regulatory databases and files
- An on-site inspection that involved:
 - Discussions with company personnel including a detailed description of facility ship scrapping operations
 - Visual inspection and review of facility operations
 - Facility records/document review
 - Collection of suspected asbestos-containing material samples for asbestos analysis, cable and paint samples for PCB analysis, wastewater samples for lead analysis, and samples of opportunity for hazardous waste characteristics
 - Identification of pollution prevention opportunities
- Exit conferences between regulatory and company personnel after the on-site inspection to discuss preliminary inspection findings
- Report preparation
- Enforcement case development and support

PREINSPECTION REVIEW

Once a facility has been targeted for inspection and a team leader assigned, available background information needs to be accessed for review. Primary sources of information are EPA, state, and local regulatory databases and files. Additional sources of information include the Occupational Health and Safety Administration (OSHA) and the Department of

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Defense's Defense Reutilization and Marketing Service (DRMS). In order to successfully bid for DOD or Maritime Administration (MARAD) vessels, the facility must submit to DRMS a technical proposal addressing how they will operate and comply with applicable environmental requirements. DRMS conducts periodic inspections of successful bidders. If the inspection is to be unannounced, each agency contacted increases the possibility of the facility learning of the inspection, whether inadvertently or not.

ON-SITE INSPECTION

NEIC conducts process-based² multimedia inspections to provide the most comprehensive evaluation of any facility. A further description of the concept of process-based inspections is presented in the March 1997 "Process-Based Investigation Guide," [Reference]. Ship scrapping operations which produce salvageable material or wastes include asbestos remediation; oil, fuel, hydraulic fluid, and lubricant reclamation; oily and contaminated water treatment and disposal; hazardous waste identification, handling, and disposal; PCB identification, handling, and disposal; and spills and associated spill reporting, prevention, control, and countermeasures. Acquiring and refining detailed operation information throughout the inspection is necessary to ensure a comprehensive multimedia inspection. Through interviews, visual observations, and record reviews, the inspector should understand all activities that generate regulated waste. The detailed description of ship scrapping operations acquired during "process" discussions should define waste streams generated, handling, and disposition.

During, and subsequent to the inspection, pollution prevention opportunities can be assessed. The company should be given the opportunity to explain what it has done to

² *Ship scrapping facilities have no real process operations or products, but produce salvageable material or wastes which will be discussed in this manual.*

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improve environmental conditions. Pollution prevention activities/environmental accomplishments of each facility and potential pollution prevention opportunities can be discussed in a "Pollution Prevention" section of the inspection report.

Before or after the process discussion, a walk-through of the facility should be conducted at the time felt most useful to the inspection team. If available, a facility plot plan and diagrams of any ships being dismantled are helpful references for the walk-through. The walk-through provides a chance to become familiar with what is described in the process discussion. Areas requiring detailed inspections or further explanations should be noted. During the walk-through inspectors usually do not take the time to don full safety gear, and there may be areas (i.e., active asbestos remediation areas) that are not surveyed during the walk-through. Restricted areas of interest should be noted and inspected later, when required levels of personnel protective equipment is worn.

Onboard ship, it is important to learn the numbering system used to designate compartments. There is a uniform numbering convention for decks and frames (bulkheads). Decks are normally numbered from the main deck with whole numbers for decks below the main deck (e.g., 2, 3, 4, etc.), and 0 numbers for decks above the main deck (e.g., 01, 02, 03, etc.). Frames or bulkheads are also numbered to identify how far aft or astern compartments are located. Inspectors should become familiar with the ship's numbering system during the walk through to facilitate correlation of locations with drawings. Inspectors can then identify specific locations targeted for more detailed inspections. Inspectors will also be able to identify locations listed on records and documents being reviewed.

Clean Air Act

Sources of air emissions for the ship scrapping industry are fires, asbestos, minor fugitive VOC emissions from waste petroleum products, and fumes from cutting torches.

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During scrapping operations, small fires are a common occurrence, when oil or sludge is ignited by cutting torches. They are usually short-lived, but may generate some intense black smoke. Open burning is normally regulated by a local ordinance or regulation.

Be aware that cables may be burned to remove coverings in order to recover copper wire. The coverings may contain PCBs and asbestos. During the inspection, the inspector should investigate any evidence of open burning and document any such occurrence. Cables can be removed by cutting with shears, power saws, or cutting torches. Cut cables with melted insulation/coverings at the cut end may be evidence of cables cut with a torch. Burning of cables may be regulated by state or local open burning regulations. In the event that cables are covered with asbestos insulation, then the asbestos NESHAP requirements would prohibit burning. Incineration of PCBs would also have to meet TSCA requirements found in 40 CFR 761.70.

There are minor fugitive losses of VOCs from oily waters and other petroleum products exposed to the atmosphere, and from natural gas or propane from cutting torches. Typically, ship scrapping facilities have not been issued operating or construction permits for air emissions sources. If permits are issued by EPA or the state or local regulatory agency, specific permit conditions need to be evaluated for compliance. If there is a lot of equipment or truck traffic on unpaved areas, fugitive dust emissions may be regulated by a State Implementation Plan (SIP). Each SIP may be different and compliance with specific requirements should be evaluated.

Asbestos remediation is a primary concern during ship scrapping and is regulated under NESHAP regulations found at 40 CFR Part 61, Subpart M. Most states have been delegated authority to inspect demolition operations and enforce federal NESHAP requirements by reference. Asbestos regulations are important to the ship scrapping industry because large volumes of asbestos waste are generated (for example, one shipbreaker was

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generating 100 tons per month of asbestos-containing waste). During the NEIC inspections in Texas, small pieces of suspected asbestos-containing material were observed on the ground at all three shipbreakers, a probable indication of noncompliance with NESHAP requirements. Two of the facilities inspected had hired contractors to train Spanish-speaking employees to remove asbestos.

The air inspection should focus on the following air emission sources: any open burning and on-going asbestos removal projects. Examples of federal and state checklists used for asbestos inspections are presented in Appendix C. Evaluating compliance should include the following:

- Daily work logs should be checked against dates on notifications. Current notifications are required for any project removing 260 linear feet of regulated asbestos-containing material (RACM) on pipes, or 160 square feet of RACM on other facility components. Although ship scrappers usually do not sample and analyze for asbestos, any surveys or sampling records should be reviewed. During the inspections in Texas, it seemed that any covering material not clearly fiberglass, was treated as RACM. Most facilities employed their own asbestos workers, who remove large amounts of RACM from the ships.
- Training records should be checked for workers and supervisors listed on work logs.
- Containment areas should be checked for proper construction, operation, and maintenance.
- Ongoing work should be observed to determine if dry removal is occurring. Are asbestos materials kept wet during demolition and properly disposed? Are cables/pipes/boilers removed with asbestos still intact? How is the asbestos on these items remediated?
- Disposal bags should be hefted to determine if waste material has been kept wet. Dry asbestos is light and fluffy. Wet asbestos is heavy and more dense.

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- Dumpsters should be checked to determine if waste material has been properly bagged. Try to check randomly picked bags from as much of the dumpster as you can readily access.
- Trucks picking up asbestos should be observed, if possible. Observe if bags are handled without bursting or dispersing asbestos to the atmosphere.
- Check facility and landfill disposal records versus dumpster logs.
- If time permits, check on the training contractor and the landfill. Do facility and training contractor records match? Does training contractor have proper training and certification? Does the landfill cover the asbestos waste daily? Is the asbestos waste placed in the landfill without dispersing asbestos to the atmosphere?
- Sample and photograph suspected asbestos-containing material found on the ground and sources, such as nearby pieces of cable, that it may have come from.
- Ask the facility to clean up, and properly dispose of, asbestos on the ground.

Asbestos is commonly found in floor tiles, gaskets, insulation, and transite pipe. Some of these materials may also contain PCBs, which is discussed later. To bid on Department of Defense (DOD) and Maritime Administration (MARAD) ships, companies must submit a technical proposal to DOD's Defense Reutilization and Marketing Service (DRMS) [the Department of Defense equivalent of GSA Surplus Sales]. In the Request for Technical Proposal (RFTP), DRMS lists the following potentially regulated asbestos waste.

- Bulkhead and pipe or thermal insulation
- Bulkhead fire shields
- Electrical cable materials
- Brake linings
- Floor tiles and deck underlay
- Steam, water, and vent flange gaskets

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- Flexitalic gaskets
- Garlock seals
- Shaft packing
- Valve packing
- Pipe hanger inserts
- Weld shop protectors, burn covers, blankets, and any fire fighting clothing or equipment

An example of an RFTP is presented in Appendix D. The company should provide handling and disposition information for the items listed above.

Clean Water Act

The CWA regulatory programs applicable to the ship scrapping industry may include:

- NPDES (including storm water)
- Pretreatment
- SPCC

Many industrial sectors generate wastewater as a byproduct or waste product of their manufacturing processes. While this is not the case with the ship scrapping industry, there are wastewaters from sources that must be managed. Wastewater sources include:

- Bilge water (stagnant, dirty water that collects in lower parts of a ship)
- Ballast water (water intentionally carried in tanks or compartments of a ship to provide stability)
- Oily water

- Fire control water

Bilge water may be contaminated with fuels or oils. Ballast water may have been chromated to prevent algal growth. During dismantling, water used in asbestos remediation may drain to lower decks and be contaminated with oil. Water used to extinguish small fires, which occur during the dismantling process, also may drain to lower decks and be contaminated with oil. As the scrapping operation progresses, more and more water accumulates in lower levels of the ship. The inspection team should consider collecting water samples from the lower decks for lead analysis. Additionally, tanks of water (sometimes previously unknown and/or sealed) may be found during scrapping.

Depending on how the wastewater is managed and where it is discharged, ship scrappers may be required to obtain an NPDES permit. States, which usually have been delegated the NPDES program, may have additional requirements. Ship scrapping facilities sometimes install oil/water separators to treat accumulations of oily water. If the water discharge goes directly to a receiving water, an NPDES permit would be required. If the water is discharged to the sewer, a pretreatment permit may be required. If permits are issued, specific permit conditions need to be evaluated for compliance. At the Port of Brownsville, Texas, ballast water could be discharged to an earthen pit operated by the port facility. If earthen pits are used, the conditions at these discharge pits and materials discharged must be evaluated. The local wastewater treatment facility should be contacted to determine if any pretreatment conditions or local limits apply to the shipbreaking facilities. Specific pretreatment conditions should be evaluated for compliance. Publicly Owned Treatment Works (POTWs) discharging more than 5 million gallons per day (MGD) are required to develop pretreatment programs. Pretreatment may be required even by POTWs discharging less than 5 MGD.

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Industrial facilities including shipbreakers must apply for storm water permits. One of the requirements of having a storm water permit is developing and implementing a storm water pollution prevention plan (SWP³). The facility has to identify sources of pollution and develop reasonable precautions, known as best management practices (BMPs), to prevent discharges of pollutants to storm water. If rainfall occurs during an inspection, drainage patterns observed should be compared to diagrams included in the SWP³. Specific permit conditions and pollution prevention plan details should be evaluated for compliance. Specific permit conditions typically include monitoring requirements to sample during rainfall events exceeding a certain threshold amount at least once a year and periodic self-inspection. Company personnel should describe how the permit conditions are monitored and how records are kept. Monitoring and inspection records should be reviewed.

To prevent accidental discharge of oil to receiving water, facilities which store over 1,320 gallons of oil in aboveground tanks (or 42,000 gallons in underground tanks), are required to have an SPCC plan. Shipbreaking facilities usually have fuel on-site for cranes and other vehicles and equipment. The facilities also generate used oil, and often store enough oil and fuel on-site to be required to have SPCC plans. Evaluating compliance should include the following:

- Determine if the plan has been certified by a professional engineer and proper facility official. The plans need to be reviewed at least every 3 years.
- Carefully review the plan to determine if the facility has addressed required items per 40 CFR 112 and then review facility operations to determine if the facility is following its plan.
- Equipment listed in the plan should be checked to see if it exists, is inspected, and is in good working order.
- Identify and visually inspect all regulated tanks, including containment and run-off control systems and procedures.

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- Check the property shoreline and adjacent water for oil sheens or other evidence of floating oil

Safe Drinking Water Act including Underground Injection Control and Public Water Supply

The SDWA regulatory programs applicable to the shipbreaking industry may include:

- Underground Injection Control
- Public Water Supply

None of the three shipbreakers at the Port of Brownsville were injecting waste into underground wells or operating a water supply system for their workers. Generally, shipbreaking does not generate large volumes of wastewater on a continuous basis that would make operation of an injection well feasible. However, if an injection well were used, it would require permits, that should be evaluated for compliance with specific permit conditions.

A public water supply system is defined as having at least 15 service connections or serving at least 25 people at least 60 days per year. To operate a public water supply system would require compliance with SDWA requirements found at 40 CFR Part 141. Because the shipbreaking facilities in Brownsville were connected to the municipal public water supply system, they are not regulated by the SDWA. The inspection should include evaluation of the water supply only if the facility is operating the system. Permits are generally not issued, but systems should be evaluated for compliance with specific permit conditions, if applicable. Maximum contaminant levels (MCLs) regulate concentration levels in water at the tap for organic, inorganic, and bacteriological contaminants including coliforms. When it is not feasible to establish MCLs, treatment techniques can be established. Examples include filtration and disinfection of surface water in lieu of an MCL for Giardia and corrosion control for facilities that exceed lead and copper action levels.

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Hazardous Waste (RCRA)

Ships from the military, including MARAD vessels, which are Reserve Fleet military vessels, have usually been demilitarized (e.g., radar and weapon systems removed) and cleaned (e.g., records, documents, cleaning supplies, unused paint removed). For example, during the inspections in Texas, the only hazardous waste at a shipbreaker, which was currently scrapping two MARAD vessels, was three drums of mercury fluorescent bulbs. The ballast in fluorescent light fixtures and many other items found on ships can contain PCBs (discussed further in TSCA PCB Regulations section). PCBs would be a significant source of hazardous waste in those states which regulate PCBs as hazardous waste. Chromated (to prevent algal growth) water from ballast tanks and oily sludges may contain heavy metals in concentrations which make it a hazardous waste. The filters from the drains under the employee showers may accumulate heavy metals and asbestos and be a hazardous waste. Unused paint or paint waste left on board may be a hazardous waste. Paints on hulls or other surfaces may contain lead, but when scrapped could possibly be excluded from RCRA regulations. The hulls or other surfaces cut up and scrapped as "processed scrap metal" (i.e., excluded from RCRA per 40 CFR 261.4), would be excluded from RCRA, if the scrap is segregated, and the steel or other metal is sent for recycling.

Commercial vessels may arrive at the ship scrapping facilities still containing miscellaneous supplies, paints, adhesives, cleaning solutions (such as solvents, alkaline detergent formulations, parts cleaners, etc.), aerosol cans, etc., that may have to be handled as hazardous wastes. For example, a shipbreaker received a barge containing items from another facility's yard such as tires filled with cement. Commercial vessels are more likely to have hazardous waste onboard or have been purposely loaded with waste material as a means of disposal.

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Depending on the volume of hazardous waste generated, shipbreakers are regulated by certain RCRA requirements [Table1]. Many shipbreakers are exempt from some RCRA requirements because they generate less than 1,000 kilograms of hazardous waste per month. If shipbreakers generate less than 100 kilograms of hazardous waste per month and do not accumulate more than 1,000 kilograms of waste at any one time, they are considered conditionally exempt small quantity generators (CESQG) and are only subject to special requirements found at 40 CFR Part 261.5. If shipbreakers generate between 100 and 1,000 kilograms of hazardous waste per month, then they are considered small quantity generators (SQG) subject to the requirements found at 40 CFR Part 262.44. If shipbreakers generate more than 1,000 kilograms of hazardous waste per month, then they are considered large quantity generators (LQG) subject to all RCRA generator requirements. Facilities may go from an LQG one month to an SQG the next month. During the months they generate over 1,000 kilograms of hazardous waste, they must comply with all of the generator requirements.

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Table 2

RCRA GENERATOR REQUIREMENTS

| Category | Quantity of Waste Generated (In one calendar month you generate...) | Applicable Requirements | Required Action |
|---|--|--|--|
| Conditionally Exempt Small Quantity Generator (CESQG) | <ul style="list-style-type: none"> - 2.2 pounds or less of acutely hazardous wastes, or - 220 pounds or less of hazardous wastes, or - 220 pounds or less of spill cleanup debris containing hazardous waste, or (At any time you...) - accumulate up to 2,200 pounds of hazardous waste on-site | <p>40 CFR 261.5</p> <p>40 CFR 262.11</p> <p>40 CFR 262.12</p> <p>40 CFR 262.20 through 262.33</p> | <p>Determine how much hazardous waste is generated and accumulated</p> <p>Conduct hazardous waste determinations</p> <p>Obtain EPA ID number, if waste shipped off-site</p> <p>Follow manifest and pre-transport requirements for waste shipped Off-site</p> |
| Small Quantity Generator (SQG) | <ul style="list-style-type: none"> - more than 220 pounds and less than 2,200 pounds of hazardous wastes, or - more than 220 pounds and less than 2,200 pounds of spill cleanup debris containing hazardous wastes, or (At any time you...) - accumulate more than 2,200 pounds of hazardous waste on-site | <p>The above requirements plus:</p> <p>40 CFR 262.34(d), (e), and (f)</p> <p>Specified requirements of 40 CFR 262.44 as follows: 40 CFR 262.40(a), (c), and (d)</p> <p>40 CFR 262.42(b)</p> <p>40 CFR 262.43</p> | <p>Meet accumulation time limits of 180 or 270 days</p> <p>Recordkeeping (manifest/waste determinations)</p> <p>Exception reporting (signed manifests not returned within 45 days)</p> <p>Additional reporting, if any, as required by EPA Administrator</p> |
| Large Quantity Generator (LQG) | <ul style="list-style-type: none"> - 2,200 pounds or more of hazardous waste, or - 2,200 pounds or more of spill cleanup debris containing hazardous waste, or - more than 2.2 pounds of acutely hazardous waste, or - more than 220 pounds of spill cleanup debris containing an acutely hazardous waste, or (At any time you...) - accumulate more than 2.2 pounds of acutely hazardous waste on-site.. | <p>All of 40 CFR 261 and 262</p> | |

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There are special requirements for handling batteries, pesticides, and mercury thermostats (universal wastes) found at 40 CFR Part 273, regardless of the amount of hazardous waste generated. State regulations vary and should always be consulted for additional and sometimes stricter requirements.

Evaluating compliance should include the following:

- Document the waste generation rate, review waste determinations and any analytical data, determine total volume of waste on-site at any time.
- All hazardous waste on-site should be inspected noting size and type of containers, condition of containers and whether containers are closed and protected from the weather.
- Check labels on the containers for the words "hazardous waste," dates, and complete information; measure volume of any secondary containment and compare to the total volume of waste stored; check that wastes have not been stored in excess of the allowable time period; check containment for cracks or leaks.
- Review any inspection records for the storage area, and check any emergency equipment such as phones, radios, spill control equipment, overpack drums, fire extinguishers, etc.
- All records need to be reviewed including annual or biennial reports. Compare wastes handled with those listed on the facility hazardous waste notification or state equivalent. Review all manifests and land disposal restriction notices for the last 3 years. Check to see if any waste shipments have been rejected and that signed return copies of all manifests are present.
- Review any training plan and check personnel records including job titles to determine when hazardous waste duties were assigned and if proper training was provided.
- Review the contingency plan, if applicable. Ask about incidents requiring implementation of the plan.

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- Inspect maintenance operations for yard equipment (cranes, winches, other vehicles) which would generate used oil. Look for parts washers/degreasers or solvent wastes.
- If filters from employee showers and wastewater collected from lower decks of the vessel are not handled as hazardous waste, samples should be collected for TCLP lead analysis.
- Ships also generate waste fuels, used oils, and sludges (from tanks) which may be hazardous wastes. Fuels and oils may be sent to reclaimers. A thorough investigation would include tracking shipments from the shipbreakers through the reclaimers to verify that shipments of fuel or oil do not contain spent solvent or other hazardous waste liquids.

Scraping operations may be conducted on unpaved sites. The ground may be covered with slag, pieces of cable, pieces of tile, occasional suspected asbestos-containing material, metal, paint chips, etc. One shipbreaker had done a limited site assessment, prior to beginning operation at the site. The site assessment revealed action levels of lead in surface soil and groundwater probably due to the presence of lead-based paint on scrapped vessels. All the sites could eventually be subject to corrective action or superfund cleanups.

It is important to track hazardous waste from cradle to grave. Inspection of the treatment, storage, and disposal facilities (TSDFs), to which hazardous waste from shipbreakers is manifested, provides information about final disposition of the waste, if necessary to reconcile facility records.

Underground Storage Tanks

Shipbreakers may have underground storage tanks. Most states have been delegated the underground storage tank programs and require that existing tanks be registered. The state programs often can provide information about whether a specific company has any registered USTs. It is important to verify registration information for each on-site UST. The

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regulations are complex and depend on the material stored in the tank, how old the tank is, what the tank is made of, and the types of monitoring equipment for the tank. As of December 22, 1998, all USTs not meeting new tank or upgrade standards must be taken out of service and removed.

TSCA PCB Regulations

EPA regulates disposal of PCBs at concentrations of 50 ppm or greater, and under current TSCA regulations, export of PCBs at concentrations of 50 ppm or greater for purposes of disposal is prohibited. Many of the uses of PCBs on ships are not authorized uses under TSCA, and unauthorized PCBs at 2 ppm or greater are not permitted to be used or distributed in commerce and must be disposed. However, in 1994, EPA proposed to allow the export of PCBs in a manner similar to the way export of hazardous waste is controlled under RCRA. Pending finalization of the export provisions, EPA entered into interim agreements with the Navy and MARAD to allow the export of ships containing PCBs for scrapping, provided specific materials were removed from the vessels prior to export. The agreements require the removal of specified liquid PCBs and solid PCB items that are readily removable. These issues are discussed in two documents titled "Shipscraping Agreements and PCBs - Background Paper" and "Administrator's Factsheet - Scrapping of Navy and Maritime Administration Ships containing PCBs" presented in Appendix E. The EPA/MARAD interim agreement is presented in Appendix F. Before conducting a PCB inspection of a Navy or MARAD ship the inspector should become familiar with the document "Sampling Ships for PCBs Regulated for Disposal" [Enclosure 4 of Appendix F]. Although whole ships can be exported per agreement, pieces of scrap steel covered with paint containing regulated amounts of PCBs is not covered by the agreements and cannot be exported. These export agreements have been suspended and their current status will always need to be determined if a ship is to be exported.

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EPA published amendments to TSCA in the June 29, 1998 Federal Register [63FR35384] which are broad and will affect sampling, analysis, and disposal of PCBs. The new amendments were effective August 28, 1998. EPA delayed addressing exports in the new rulemaking, so current Navy and MARAD agreements addressing export of PCBs are still applicable and remain applicable even with the new amendments in effect.

PCBs are second only to asbestos as a primary environmental concern during scrapping. In the RFTP, DRMS lists the following potentially regulated PCB waste.

- Transformers
- Capacitors
- Electrical cable
- Insulation
- Felt gaskets
- Thermal and acoustic insulation materials
- Aluminized paint
- Various rubber and plastic products

Shipbreakers often sample for PCBs because EPA has presumed certain items contain PCBs at regulated concentrations of 50 ppm or greater, unless sampling and testing results prove a lesser concentration. The new amendments to TSCA change some of the assumptions, but because shipbreaking facilities are dealing with electrical equipment, which is being disposed of, the assumption policies of 40 CFR Part 761.2 do not apply. The facilities must know the actual PCB concentration and use the proper disposal method. The following items are presumed to contain PCBs.

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- Cable insulation
- Rubber and felt gaskets
- Thermal insulation material including fiberglass, felt, foam, and cork
- Transformers, capacitors, and electronic equipment with capacitors and transformers inside
- Voltage regulators, switches, reclosers, bushings, and electromagnets
- Adhesives and tapes
- Oil including electrical equipment and motors, anchor windlasses, hydraulic systems, and leaks and spills
- Surface contamination of machinery and other solid surfaces (unknown sources presumably from historic practices)
- Oil-based paint
- Caulking
- Rubber isolation mounts
- Foundation mounts
- Pipe hangers
- Light ballasts
- Any plasticizers

The presumptions that the above items contain PCBs, plus information on sampling and analysis, are defined in a November 30, 1995 letter to MARAD [Appendix F]. Additionally, the August 5, 1996 response to the MARAD enforcement discretion extension letter contains sampling and analysis guidance for PCBs in paint [Appendix G]. Note this draft guidance has not been peer reviewed.

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Evaluating compliance should include the following:

- Disposition of the materials listed above needs to be checked during the inspection. The shipbreakers NEIC inspected were not testing or handling fiberglass insulation as PCB or PCB-contaminate items.
- PCB waste should be tracked through to the disposal facilities, similar to tracking RCRA waste, if necessary to reconcile facility records.
- Sampling plans and laboratory results need to be reviewed. None of the shipbreakers NEIC inspected had their own laboratory. The local laboratory used by some of the shipbreakers was not analyzing PCB samples properly and the accuracy of analytical results was questionable. The inspection team needs to include someone who can conduct laboratory audits [see following section on conducting laboratory audits].
- Determine the 100-year floodplain location with respect to any storage-for-disposal area. Many shipbreakers are located within the 100-year floodplain and cannot have storage-for-disposal areas. Has the storage-for-disposal area been approved by EPA?
- Any PCB temporary storage area or storage-for-disposal area should be inspected. The storage area must be protected from the elements. Labels and PCB marks should be checked on each item in storage.
- The floor and curb of any storage-for-disposal area should be checked for cracks and the curb measured to determine if it is at least 6 inches high. Capacity of the storage area should be checked against the total volume of PCBs in storage.
- All records should be reviewed including manifest and disposal records and annual documents and notices to local fire departments. EPA and building owners have to be notified of the location of PCB transformers after August 28, 1998.

At the beginning of the inspection, a Notice of Inspection and a TSCA Inspection Confidentiality Notice must be issued to appropriate facility personnel. Before leaving the

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site, the following two forms are issued: a Receipt for Samples and Documents and a Declaration of TSCA Confidential Business Information (CBI).

Conducting Laboratory Audits

The purpose of laboratory evaluations and data quality assessment is to determine if analytical and monitoring needs have been satisfied, and to assess data usability. Two approaches are used, performance audits and systems audits. A performance audit assesses results and usually does not examine the intermediate steps used to achieve those results. A systems audit typically involves an inspection of the components comprising the total measurement system; that approach is discussed in the following paragraphs. For ship scrapping two possible approaches to a performance audit are:

- The analysis of a reference material (performance evaluation sample)
- Splitting samples between two laboratories, one hopefully having trusted performance

Performance evaluation (PE) samples for PCB analysis only exist for liquid or soil matrices. However, a ship scrapper might retain a portion of cable which tested positive for PCBs, and use that as a PE sample over a period of time to monitor a laboratory or laboratories for consistency of results. An inspector may request a portion of the PE cable for independent analysis.

EPA guidance for sampling of ship scrapping non-liquid PCB materials is presented in Enclosure 4 of Appendix E. Understanding the sampling strategy used at the site, including how material is treated/handled when results are positive is necessary. There should be an organized, understandable system for segregating materials according to positive PCB results or negative results, and for how similar unsampled still-in-place

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materials are treated. In other words, the applicability, and implications for further action, of sampling results to material either removed or still on the ship should be known.

The laboratory will very likely not be a source of much sampling information, but laboratory personnel may be listed as sample collectors. If personnel from the lab are listed as sample collectors inquire about the extent of their activity and did they prepare and/or follow a sampling plan. Did they select sampling locations or just sample what they were told to sample by the facility? The latter is reasonable, since it is doubtful that someone unfamiliar with ship scrapping would understand and effectively use an appropriate sampling plan.

Analytical Methods

Analytical methods are specified in Appendix 1 of Enclosure 4 [Appendix F]. The approach is soxhlet extraction using toluene as solvent equivalent to SW-846 Method 3540; extract clean-up by partitioning with concentrated sulfuric acid; followed by extract analysis by Method 8082, the most recent SW-846 gas chromatographic (GC) method for PCBs. The SW-846 manual presents extraction and instrument methods. Organic extraction methods have numbers in the 3400 series, and instrument methods are in the 8000 series. Letters behind the number indicate revisions of the methods, usually because of corrections to text or additions of performance data, rather than to present significant changes to the details of performing the method; major changes to methods are usually given a new method number. For example, Method 8082 is the instrument method for analysis of PCBs using capillary GC columns with electron capture detection. The science involved is essentially the same as for Method 8080, which was for analysis of organochlorine pesticides and PCBs using packed columns. When capillary columns became prevalent in laboratories, specific methods were written for pesticides (8081, although early versions included PCBs) and PCBs (8082). This background is presented because Enclosure 4 mentions some of these other methods.

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Method 8280 is for analysis of chlorinated dioxins and dibenzofurans, and the method number in Enclosure 4 should be 8082. The implementation of performance based measurement systems (PBMS) may end regulatory requirement to use specific methods, although ship scrapping contracts may specify methods for that contract.

Sulfuric acid clean-up of the sample is effective and relatively easy compared to other clean-up approaches, and has been used for decades for PCB analysis. The clean-up takes advantage of the chemical inertness of PCBs. Concentrated sulfuric acid will react with many compounds which would be chromatographic interferences in the analysis, yet will not affect the major PCB components of Aroclor mixtures. The reaction products partition into the sulfuric acid layer during the clean-up and are removed from the extract before GC analysis. The EPA Region 6 laboratory has found that the toluene extract from cable samples (and presumably other types of samples) did not give a distinct separation of solvent and sulfuric acid layers during the clean-up, but that diluting the toluene with hexane gave an effective separation, as well as a solution appropriate for GC analysis.

Laboratory Audit

At the laboratory, the auditor will probably first talk to the manager or quality assurance officer. They should discuss general procedures the lab uses for ship scrapping samples. In addition to analytical procedures (which should be those discussed above), the following should be verified.

- Who collects samples
- Who selects sample locations/what samples to collect
- Review sampling plan
- How samples are prepared for analysis

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- What portions of cable samples are analyzed
- What is the particle size of sample portions extracted
- How calibrations are performed
- How Aroclors are quantitated (are quantitative results based on standards of the Aroclor detected in the sample?)
- How spiking is performed, what the spike concentration is in terms of sample concentration (if you care about 50 parts per million in a sample, spikes at 500 ppm are of questionable value).
- What happens on real samples (this can be verified by talking to the personnel actually performing the analysis)
- How QC procedures are conducted (obtain a QC package for each type of analysis performed)

Particle size reduction for rubber-like materials is important so that the solvent can better penetrate the interior of particles. A particle size of 1 mm is preferable, but if rubber particles are no more than 2 to 3 mm in their largest dimension, the laboratory is probably doing a better job than many laboratories. The size reduction can be very labor intensive and is an obvious opportunity for short cuts.

Look at chromatograms of ship scrapping samples and of Aroclor standards. The peak widths seen in samples and the general appearance of the chromatogram should be similar to standards when observed from 5 feet away. That is, sample chromatograms should not be dominated by flat-topped blob peaks a minute or more in width, although they may be observed occasionally without great concern. Such peaks are interferences in the analysis. If they obscure enough of the chromatogram within the retention time range of Aroclor mixtures so that at least a portion of the Aroclor pattern could not be identified, they prevent accurate quantitation of Arochlor present in the sample.

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Close comparison of standard and sample chromatograms should allow anyone to confirm or deny the presence of an Aroclor mixture. Samples will typically contain additional peaks which will confuse the issue, but if the laboratory has reported PCBs in a sample, you should be able to pick out a pattern of peaks due to the Aroclor mixture. Conversely, if you see a pattern of peaks in a sample for which the lab has not reported PCBs as being present, laboratory personnel should be able to convince you by comparing retention times and the overall pattern of sample and standards that no Aroclor mixture is present. If this cannot be done, you have reason to question the accuracy of their results. Most laboratories will have a computer-based data system for acquiring and processing GC data. The data system should be able to produce magnified displays of portions of a chromatogram of interest so that close comparison of sample to standard chromatograms can be made.

A certain indication of problems with the capability of the laboratory to perform reliable PCB analysis is repeatedly seeing sample chromatograms for reported data which "go off scale" and stay there until the data system stops collecting data at the end of the run, or data where a huge lump peak obscures the majority of the chromatogram. It is appropriate to consider such samples as "not analyzed." If a lab has reported "none detected" for such a sample because "they didn't see any indication of PCBs," the truth is more accurately "they have no idea what might be there."

The chromatograms of blanks should have no more than a few small peaks, and preparation blanks should not look greatly different than pure solvent injected on the GC. Be aware that the GC data system will probably normalize the scale of a chromatogram to the largest peak in the display. This normalization can make a "clean" chromatogram look bad. You can expect somewhere on a chromatogram to see a number indicating the height of the largest peak, or the scale of the chromatogram. If this number is on the order of six to eight digits for standards, and three or four digits for the preparation blank, it is acceptable

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even if the picture of the chromatogram is "ugly"; the response of the blank is insignificant compared to concentrations of interest.

Potential problems observed during an audit should be supported by documentation. Get copies of data and have specific sources for information and examples of things you believe are problems. Consider requesting splits of problem samples.

Under the PCB Disposal Amendment, Final Rule published in the Federal Register June 29, 1998, the non-liquid PCB items from ship scrapping operations such as cable insulation, felt pads, and rubber gaskets are classified as PCB bulk product waste. This may affect how future sampling and analysis are conducted. These amendments were effective August 28, 1998.

EPCRA

The ship scrappers are not manufacturers and would not have to do release reporting under Section 313, but would be subject to spill reporting. None of the facilities NEIC visited/inspected had reported any spills. Any spill records should be checked for time of the event and time of reporting to regulatory agencies (state emergency response commission, local emergency planning committee, and National Response Center for spills involving reportable quantities) including written follow-up reports. The Coast Guard (National Response Center) can be contacted for a list of reported spills, and/or the local Coast Guard Station can be contacted to see if it has responded to spills at the facility.

There is also a requirement under EPCRA [40 CFR Part 370] for reporting any inventory of hazardous chemicals used on-site where there is 10,000 pounds stored on-site at any time. Hazardous chemicals (basically anything that needs a material safety data sheet

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[MSDS]) may include liquid oxygen and other chemicals used to supply the cutting torches. There is no SIC code limitation.

FIFRA

Tributyl tin (TBT) paint (anti-fouling paint) is considered a pesticide. Unused paint or paint waste may be subject to label disposal directions and/or RCRA regulations. Paint on hulls cut up for scrap would be excluded from RCRA regulations, provided the scrap is segregated. The scrap steel and other metals are considered processed scrap metal and excluded from RCRA regulation.

Other/Miscellaneous

Ship scrapping facilities may dredge their slips, and piles of dredge spoils, containing unknown materials, may be observed at the site. The ship scrapping facility would need to obtain a Corps of Engineer permit for the dredging. The dredge spoils may contain pieces of rope, cable, etc., similar to what is found on the ground at this facility and at other shipbreakers. The dredge spoils might also exhibit lead contamination similar to the surface soil at other facilities.

EXIT CONFERENCE

During the exit conference between regulatory and facility personnel, inspection personnel should stress that the findings are preliminary and final determinations will be made in conjunction with regional and state personnel. The facility should be encouraged to provide a follow-up status report of subsequent actions taken to address inspection findings. The facility should be informed that the status report will be included as an appendix to the inspection report if it is received before the inspection report is finalized.

INVESTIGATION REPORT

After the on-site inspection is completed, information obtained is further evaluated and findings/conclusions are developed. An investigation report is then written to present the findings, conclusions, and supporting information in a logical, organized manner. Reports should be prepared and peer-reviewed before they are published in final form. The procedure involves developing one or more drafts for review. Upon receipt of comments on the review draft, a final report is prepared. The final report is the basis for follow-up activities or enforcement actions that might be initiated.

Inspection reports are prepared by the appropriate individual or project team member(s) under the direction of the team leader. All participants in the report preparation process must assure that their individual contributions are accurate, relevant, objective, clear, fully supportable, and commensurate with agency policy. Supporting information and documents used or referred to in the report are implicitly endorsed, unless disclaimed. Report authors are responsible for determining where such disclaimers are needed. Although the overall responsibility for the preparation and content of the reports rests with the investigation team leader, team members are responsible for the quality, accuracy, and admissibility of information in the final report.

Many different formats are possible for the investigation report. However, to produce a cohesive, readable document, it is recommended that a single multimedia report be prepared. The potential audience for a multimedia inspection report may be diverse and includes not only technical peers, but also managers, lawyers, judges, reporters, informed citizens, and other non-technical readers. The reports should be written for this diverse audience.

**MULTIMEDIA COMPLIANCE MONITORING INVESTIGATION PROTOCOL
FOR THE SHIP SCRAPPING INDUSTRY**

Readability of the comprehensive multimedia reports may be enhanced by organizing the report into two major sections: the Executive Summary and the Technical Report. The Executive Summary section clearly states inspection objectives, discusses relevant background information, summarizes inspection methods, and as appropriate, presents conclusions regarding facility compliance which are supported by a brief summary of the findings. The Summary should include specifics to accurately determine whether a violation has occurred (e.g., "insufficient aisle space" does not provide sufficient detail; "aisle space less than 15 inches" is acceptable). The Technical Report section more comprehensively describes the inspection, giving specific details about the findings, including sample collection and analysis, and other pertinent aspects of the investigation. Findings in the Executive Summary must correlate to and be supported by discussion in the Technical Report.

Distribution of final reports is coordinated with the requesting office, program office, and Regional counsel. Reports containing confidential business information (CBI) per 40 CFR Part 2 will be subject to distribution restrictions. EPA reports containing material asserted to be CBI by the company may not be shared with non-Federal agencies without obtaining specific authorization from the company. Within EPA, reports are often "Enforcement Confidential" and distribution is restricted per organizational policies.

REFERENCES

RCRA Inspection Manual, 1993 Edition, OSWER 9938.2A

TSCA Inspection Manual, Volume 2 - PCB Inspection Manual, March 1981

EPA Guidance for Controlling Asbestos-Containing Materials in Buildings - OPTS
EPA 560/5-85-024 June 1985

Pesticides Inspection Manual, January 1989, OPTS

Process-Based Investigation Guide, March 1997, EPA report number: EPA-330/9-97-001, also available on the internet at <http://www.epa.gov/oeca/oceft/neic/pubs.html>

APPENDICES

- A Sources of Summaries of Applicable Environmental Laws
- B Safety Plan
- C Examples of State and Federal (NESHAP) Asbestos Checklists
- D Request for Technical Proposal
- E Ship Scrapping and PCBs - Background Paper and Administrator's Factsheet
- F November 30, 1995 Letter to MARAD
- G August 5, 1996 Response to MARAD Extension Letter

APPENDIX A
SOURCES OF SUMMARIES OF APPLICABLE ENVIRONMENTAL LAWS

NEIC Multimedia Investigation Manual - Revised March 1992, EPA report number: EPA-330/9-89-003-R, ISBN: 0-86587-300-3

NETI-West Multimedia Inspector Training Course Manual - March 1996

NETI-West Basic Inspector Training Course Manual - July 1997

EPA Generic Protocol for Environmental Audits at Federal Facilities - August 1989, EPA report number: EPA/130/4-89/002

Compact Disc from NETI on Major Environmental Statutes - 1998

Environmental Law Handbook, 14th Edition, Thomas F.P. Sullivan, from Government Institutes, Inc.

APPENDIX B
SAFETY PLAN

Appendix B

NEIC SITE HEALTH AND SAFETY PLAN

General Information

1. Project Title: _____ Project Number: _____

2. Location: _____

3. Description of Field Activities: _____

4. Date of Field Activities: _____

5. NEIC Personnel:

| |
|------------------------|
| Project Leaders |
| |
| |

6. Contractor Personnel: Must be OSHA certified per 29CFR1910.120.
(N/A) **Obtain list of personnel, duties or work to be performed, and copies of training certificates.**

Emergency Information

7. Ambulance: _____ Phone: _____

8. Hospital: _____ Phone: _____
_____ (emergency room)

9. Emergency Route: _____

10. Fire Department: _____ Phone: _____

11. Police: _____ Phone: _____

12. Poison Control Center: _____ Phone: _____

13. Site Emergency Notification/Evacuation Method: _____

14. NEIC Health and Safety Officer:

Steve Fletcher - 303-236-5111, Ext.283

15. Radiation Safety Assistance:

Jed Harrison, Director
Office of Radiation

Programs

Las Vegas Facility
702-798-2476

Hazard Evaluation

16. Check all known or potential hazards: Radiation Toxics Fire/Explosion
 O2 Deficiency Corrosives Noise Physical Biological Dusts
 Heat/Cold Stress

NOTE: DISCUSS HAZARDS AND PRECAUTIONS IN DETAIL IN WORK PLAN BELOW.

17. Specify unusual working conditions/limitations (excavations, confined spaces, lagoons, elevated, surfaces, weather, darkness, etc.)*

* Attach specific hazard management plans, if applicable.

18. Potential Chemical Hazards:

| CHEMICAL | TLV/ IDLH | ROUTE OF EXPOSURE | ACUTE SYMPTOMS | ODOR LEVEL | ODOR/VISUAL DESCRIPTION |
|----------|-------------------------------------|-----------------------|----------------------------------|---------------|---|
| Asbestos | 0.1 fiber/cm ³ PEL | Inhalation, ingestion | Restricted pulmonary function | N/A | White or greenish, blue, or gray-green fibrous solids |
| | | | | | |
| | | | | | |
| | | | | | |

Work Plan

19. List tasks, anticipated hazards checked above, and control measures which will be taken, including levels of protection:

| Task | Hazards | Level of Protection (A,B,C,D) and Control Measures |
|------|---------|--|
| | | |
| | | |
| | | |

20. Health Hazard Monitoring Plan:

| Constituent | Type of Sample | Frequency | Instrument | Notes |
|-------------|----------------|-----------|------------|-------|
| | | | | |

21. Site Control/Security Measures: _____

22. Decontamination Procedures (personnel hygiene, contaminated clothing, equipment, instruments, etc.): _____

23. Disposal Procedures (contaminated equipment, supplies, decontamination solutions, etc.): _____

Approvals

This site HASP has been reviewed and constitutes the minimum anticipated safety requirements for personnel engaged in field activities at this project site. However, the Project Leader has the authority to change these requirements, based upon the conditions present at the site.

Approved by:

24. Project Leader: _____ Date: _____

25. Branch Chief: _____ Date: _____

26. Health & Safety Officer: _____ Date: _____

SITEHASP.SAF: 03/92

APPENDIX C
EXAMPLES OF STATE AND FEDERAL (NESHAP)
ASBESTOS CHECKLISTS

**Texas Department of Health
Site Inspection Checklist / NESHAP & TAHPA**

| ON-SITE RECORDS/DOCUMENTS: | YES | NO | UNK | N/A |
|---|------------|-----------|------------|------------|
| 1. Applicable Regulations 295.58(k) | ___ | ___ | ___ | ___ 1. |
| 2. Roster of on-site registered workers 295.62(c)(2)(M) | ___ | ___ | ___ | ___ 2. |
| 3. Workers annual physicals 295.58(c) | ___ | ___ | ___ | ___ 3. |
| 4. Workers fit test records 295.58(c) | ___ | ___ | ___ | ___ 4. |
| 5. Copy of work & personal safety practices 295.62(c)(2)(A),(J) | ___ | ___ | ___ | ___ 5. |
| 6. Daily sign-in/sign-out sheets 295.62(c)(2)(E) | ___ | ___ | ___ | ___ 6. |
| 7. Copy of contract specifications 295.62(c)(2)(B) | ___ | ___ | ___ | ___ 7. |
| 8. Name and address of supervisors(s) 295.62(c)(2)(I) | ___ | ___ | ___ | ___ 8. |
| 9. On-site air monitoring (i.e. personal) 295.62(c)(2)(F) | ___ | ___ | ___ | ___ 9. |
| 10. Written respirator program 295.62(c)(2)(G) | ___ | ___ | ___ | ___ 10. |
| 11. Required documents posted 295.58(j) | ___ | ___ | ___ | ___ 11. |
| 12. Evidence of NESHAP training 61.145(c)(8) | ___ | ___ | ___ | ___ 12. |

| ABATEMENT PRACTICES AND PROCEDURES: | YES | NO | UNK | N/A |
|---|------------|-----------|------------|------------|
| 13. Was ACM survey conducted 295.34(c) 61.145(a) | ___ | ___ | ___ | ___ 13. |
| 14. Notification submitted 295.61(a) 61.145(b) | ___ | ___ | ___ | ___ 14. |
| 15. Activities according to notification 295.61(d),(e) 61.145(b)(2) | ___ | ___ | ___ | ___ 15. |
| 16. Project began on notification start date 295.61(f) 61.145(b)(3) | ___ | ___ | ___ | ___ 16. |
| 17. ACM removed before demo/reno activities 61.145(c)(1) | ___ | ___ | ___ | ___ 17. |
| 18. Are wet methods being used 295.60(h) 61.145(c) | ___ | ___ | ___ | ___ 18. |
| 19. ACM thoroughly wet 295.60(j)(1) 61.145(c)(2),(3),(4) | ___ | ___ | ___ | ___ 19. |
| 20. Units carefully lowered 295.60(j)(2)(B) 61.145(c)(2) | ___ | ___ | ___ | ___ 20. |
| 21. HEPA ventilation was used 295.60(i) 61.145(c) | ___ | ___ | ___ | ___ 21. |
| 22. Negative air pressure of at least 0.02 inches of H ₂ O 295.60(l) | ___ | ___ | ___ | ___ 22. |
| 23. HEPA vacuum available 295.60(h) | ___ | ___ | ___ | ___ 23. |
| 24. Component(s) sealed 295.60(j)(2) 61.145(c) | ___ | ___ | ___ | ___ 24. |
| 25. Sealed components(s) labeled 295.60(j)(2) 61.150(a) | ___ | ___ | ___ | ___ 25. |
| 26. Are danger signs in English/Spanish 295.60(g) | ___ | ___ | ___ | ___ 26. |
| 27. Is regulated area clearly marked 295.60(a)(3) | ___ | ___ | ___ | ___ 27. |
| 28. Is regulated area established 295.59(b)(2) | ___ | ___ | ___ | ___ 28. |
| 29. Are critical barriers properly established 295.60(b) | ___ | ___ | ___ | ___ 29. |
| 30. Is there a "three stage" decon 295.60(e) | ___ | ___ | ___ | ___ 30. |
| 31. Is supervisor present 295.58(b)(2) 61.145(c)(8) | ___ | ___ | ___ | ___ 31. |
| 32. Is supervisor in containment at least 25% of the time 295.58(b)(3) | ___ | ___ | ___ | ___ 32. |
| 33. 1 fire extinguisher per 1000 sq ft 295.60(m)(1) | ___ | ___ | ___ | ___ 33. |
| 34. GFCI units installed within area 295.60(m)(2) | ___ | ___ | ___ | ___ 34. |
| 35. Is the HVAC shut down in work area 295.60(f) | ___ | ___ | ___ | ___ 35. |

| WASTE DISPOSAL PROCEDURES: | YES | NO | UNK | N/A |
|---|------------|-----------|------------|------------|
| 36. Visible emissions 61.150(a) | ___ | ___ | ___ | ___ 36. |
| 37. Is ACWM double bagged 295.60(j)(2) | ___ | ___ | ___ | ___ 37. |
| 38. Is ACWM in bags thoroughly wet 295.60(j)(3) 61.150(a)(1)(iii) | ___ | ___ | ___ | ___ 38. |
| 39. Do bags have OSHA warning labels 61.150(a)(1)(iv) | ___ | ___ | ___ | ___ 39. |
| 40. Do bags have generator labels 61.150(a)(1)(v) | ___ | ___ | ___ | ___ 40. |
| 41. ACWM to be disposed of at an approved site 61.150(b) | ___ | ___ | ___ | ___ 41. |
| 42. OTHER: _____ | | | | |

INSPECTOR(S) NAME: _____
 INSPECTOR(S) SIGNATURE _____ DATE _____

SITE SUPERVISOR SIGNATURE _____ DATE _____

Your signature only verifies the inspection results were discussed with you.

The above information will be forwarded to the Texas Department of Health, Austin office for further review. Possible Notices of Violations may be written.

**TEXAS DEPARTMENT OF HEALTH
ASBESTOS DEMOLITION AND RENOVATION
SITE INSPECTION CHECKLIST/NESHAP AND TAHPA**

Notification #: _____ Date /Time of inspection: _____

Facility Location/Name: _____

Public Health Region / Local Program: _____ County: _____

NESHAP: _____ TAHPA: _____ Notification Priority: _____

Reason for Inspection: (Circle those applicable)

DEMOLITION RENOVATION O & M PHASED COMPLAINT COMPLIANCE

OTHER: _____

Building Owner: _____ TDH License No: _____

Contractor: _____ TDH License No: _____

Individual Consultant: _____ TDH License No: _____

Consultant Agency: _____ TDH License No: _____

Project Supervisor: _____ TDH License No: _____

Air Monitor/Lab: _____ TDH License No: _____

Transporter: _____ TDH License No: _____

Name(s) and Position(s) of Other Person(s) Interviewed:

What type of ACM or Suspect ACM is involved in the Project (i.e. insulation, floor tile, roofing, etc.)?:

Is the Material Friable/Regulated?: _____

Describe Current Stage of the Project (i.e. prep, removal, clearance, etc.):

Note any changes in the Information Provided on the Notification: _____

When did work that disturbed ACM start (if different from notification)?: _____

Waste Disposal Site: _____

Comments/Summary of Recommendations / Discussion with Owner/Operator:

Was Containment entered by Inspector(s)?: 1. YES/NO _____(initial) 2. YES/NO _____(initial)

ABBREVIATED CHECKLIST FOR MAP COMPLIANCE
(PUBLIC AND COMMERCIAL BUILDINGS)
FOR USE ON NESHAP INSPECTIONS

I. GENERAL INFORMATION

Name of Facility _____

Address _____
(City, State, Zip code)

Owner Name _____

Contact Person _____

Address _____
(City, State, Zip Code)

Phone Number _____

Date of inspection: _____ Time of inspection: _____

Reason for inspection: _____

Routine Compliance Inspection: _____ Citizen Complaint _____

Response Action Inspection: _____

Other (explain): _____

II. Definition of Public and Commercial Building:

The interior space of any building which is not a school building, excluding residential apartment building of fewer than 10 units or detached single-family homes. The term includes, but is not limited to industrial and office buildings, residential apartment buildings and condominiums of 10 or more dwelling units, government-owned buildings, colleges, museums, airports, hospitals, churches preschools, stores, warehouse, and factories. Interior space includes exterior hallways connecting buildings, porticos, and mechanical systems used to condition interior space.

111. OPENING CONFERENCE

1. Personnel present and interviewed:

Name: _____ Title: _____

Name: _____ Title: _____

2. EPA inspector accompanied by other State or Federal employee(s)

Yes _____ No _____

Name: _____ Agency: _____

Name: _____ Agency: _____

3. Credentials presented to: _____

4. Notice of Inspection signed and a copy provided to official?

Yes _____ No _____

IV. INSPECTION

Abatement Project Description (size of project, type of material, methods used):

Was the Building initially inspected for asbestos:

Yes _____ No _____

Name of Inspector: _____

Accreditation Number _____ Date _____

Name/Address of Training Provider _____

V. Provide accreditation of contractors and workers:

Name/Address of Contractor _____

Contractor/Supervisors:

1. Name: _____ **Accreditation #:** _____ **Date** _____

Name/Address of Training Provider _____

2. Name: _____ **Accreditation#:** _____ **Date** _____

Name/Address of Training Provider _____

Project Designer: _____ **Accreditation#:** _____ **Date** _____

Name/Address of Training Provider _____

Workers:

1. Name: _____ **Accreditation #:** _____ **Date** _____

Name/Address of Training Provider _____

2. Name: _____ **Accreditation#:** _____ **Date** _____

Name/Address of Training Provider _____

3. Name: _____ **Accreditation#:** _____ **Date** _____

Name/Address of Training Provider _____

4. Name: _____ **Accreditation#:** _____ **Date** _____

Name/Address of Training Provider _____

5. Name: _____ **Accreditation#:** _____ **Date** _____

Name/Address of Training Provider _____

6. Name: _____ Accreditation#: _____ Date _____

Name/Address of Training Provider _____

7. Name: _____ Accreditation#: _____ Date _____

Name/Address of Training Provider _____

8. Name: _____ Accreditation #: _____ Date _____

Name/Address of Training Provider _____

9. Name: _____ Accreditation#: _____ Date _____

Name/Address of Training Provider _____

VI. Air monitoring data

Was air clearance performed? Yes _____ No _____

1. Name and Address of Laboratory: _____

Accreditation #: _____ Date _____

Contact Person: _____ Phone Number _____

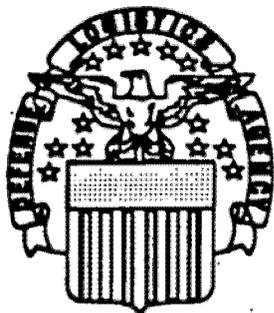
Type of Analysis: TEM _____ PCM _____

VII. POST INSPECTION INTERVIEW

Inspector Signature
Revised on 10/29/97

Date

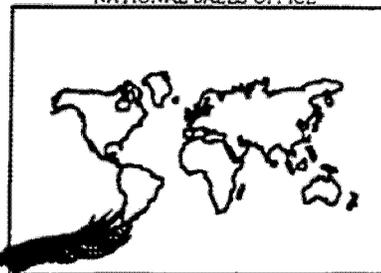
APPENDIX D
REQUEST FOR TECHNICAL PROPOSAL



DEFENSE DE SYLVAIUM AND BANNET 100 000 000

DEPARTMENT OF DEFENSE

NATIONAL SALES OFFICE



SPANNING THE WORLD TO TARGET THE MARKET

REQUEST FOR TECHNICAL PROPOSAL (RFTP) 31-8018

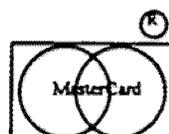
RFTP Opening Date and Time
APRIL 30, 1998; 4:30 P.M. EASTERN TIME
Inspection Period Begins: March 16, 1998

This RFTP is for 13 ships located on the West Coast.

Inspection is mandatory.

Inspection period ends on April 24, 1998. Seven days notice required prior to inspection.

Proposed Invitation For Bid is provided for information purposes only.



REQUIREMENTS AND CRITERIA FOR TECHNICAL PROPOSALS
(FOR DOMESTIC SCRAPPING)

EACH BIDDER MUST INSPECT EACH SHIP ON WHICH IT INTENDS TO BID PRIOR TO SUBMISSION OF ITS TECHNICAL PROPOSAL IN ORDER FOR THE PROPOSAL TO BE TECHNICALLY ACCEPTABLE. THIS INSPECTION IS MANDATORY AND MAY NOT BE WAIVED. Bidders are strongly advised to review the pre-disposal documentation, including hazardous material inventories and surveys, which will be distributed at the time of ship inspection. BIDDERS MUST CERTIFY RECEIPT OF THE PRE-DISPOSAL DOCUMENTS AT THE TIME OF INSPECTION OF THE SHIPS. Bidders who do not inspect the ship during the advertised inspection period as verified by the U.S. Government log entry, and certify receipt of pre-disposal documentation will not be eligible to participate under Step 2 of this process.

BIDDERS ARE ENCOURAGED TO PERFORM A THOROUGH INSPECTION OF THE SHIP TO DETERMINE THE MAJOR EQUIPMENT REMAINING ON BOARD.

Potential bidders must provide the following information for each person inspecting the ship. This information will be used to obtain a security clearance to enter the shipyard. The information must be submitted at least 7 calendar days in advance of the date of inspecting the ships:

Name
Social Security Number
Employer

For items 1-10 and item 13 this information can be faxed to (360)476-8665 or mailed to:

Naval Sea Systems Command Detachment
Naval Inactive Ship Maintenance Facility
(PSNS B-550)
2450 Wycoff Way
Bremerton, WA 98314-5250
Point of Contact: Pete Galassi

For items 11-12, this information can be faxed to (808)471-4524 or mailed to:

Naval Sea Systems Command Detachment
Naval Inactive Ship Maintenance Facility
93-051 Waipio Point Access Road
Waipahu, HI 96797-3272
Point of Contact: Walt Leonard

INSPECTION DATE (EXCLUDES SATURDAYS, SUNDAYS, AND FEDERAL/NATIONAL HOLIDAYS). BEGINS: March 16, 1998, 8:00 A.M. TO 3:00 P.M., LOCAL TIME:

- o ITEM(S): HOURS:
 1-13 APPT ONLY

Bidder's may submit more than one technical proposal for this RFTP. If the bidder intends to bid on multiple lot(s)/item(s), the technical proposal(s) must demonstrate the capability and facilities to process multiple lot(s)/item(s) concurrently. BIDDERS SUBMITTING A TECHNICAL PROPOSAL FOR ITEM 13 (EX-ORISKANY) ARE REQUIRED TO SUBMIT A SEPARATE TECHNICAL PROPOSAL FOR THIS ITEM. The bidder shall submit an original and 4 copies for each technical proposal submitted in response to this solicitation, subject to the following requirements and limitations:

A. Company Name: The company name shall appear on the title page only. All other references to the company name shall be removed from the technical proposal.

B. Title Page: "Unpriced Technical Proposal". The title page of each technical proposal shall include: (1) the lot and/or item number, and name of the ships for which you are submitting a technical proposal; (2) solicitation number of the Request for Technical Proposal (RFTP); (3) the company name of the bidder; and (4) the bidder's position regarding disclosure of proprietary or similar proposal data.

C. Table of Contents: The table of contents shall identify the major sections of the total proposal and show location and page numbers of each section.

The technical proposal is the primary basis for the evaluation of: (a) the degree to which the bidder's claims of performance capacity are supported, and (b) the ability of the bidder to perform in accordance with the requirements. The technical factors to be considered are those discussed herein.

Bidders are cautioned to pay particular attention to the following factors in preparing their technical proposals and to provide sufficient detail in those proposals to demonstrate their complete understanding of the true scope of the work involved, including the requirement to perform all contract requirements in compliance with all Federal, State, and local laws and regulations. The technical factors include:

- Environmental Compliance Plan
- Operational Plan
- Business and Management Plan
- Safety and Health Plan

The technical proposal shall be sufficiently detailed, specific and complete as to enable Government personnel to make a thorough evaluation of the proposal and a sound determination that the bidder will have a reasonable likelihood of meeting the

requirements and objectives of the Government as set forth in the Invitation for Bids. The technical proposal shall clearly and fully demonstrate that the prospective bidder has a valid and practical solution to the technical problems and risks inherent in ship dismantling. General statements to the effect that the prospective bidder understands, can, or will comply with all Federal, State, local laws and regulations or phrases such as "Standard Procedures will be used" or "Well-known techniques will be utilized" and generalities of textbook theories and techniques, or quotation of regulatory requirements will not constitute compliance with these requirements concerning the content of the technical proposal.

The following Technical Proposal organization is required to facilitate the technical evaluation:

- A. TITLE PAGE
- B. TABLE OF CONTENTS
- C. ENVIRONMENTAL COMPLIANCE PLAN
- D. OPERATIONAL PLAN
- E. BUSINESS AND MANAGEMENT PLAN
- F. SAFETY AND HEALTH PLAN
- G. DRAWINGS
- H. LIST OF APPENDICES

APPENDICES: Supplementary or supporting data as necessary.

TECHNICAL FACTORS

1. ENVIRONMENTAL COMPLIANCE PLAN: All bidders are advised that they and any subcontractors must comply with all applicable Federal, State, and local laws, ordinances and regulations. Provide the following information for the bidder and all subcontractors who will perform work under this contract:

A. Provide the procedures for identification (testing), abatement, removal, treatment, storage, transportation and disposal of all potentially regulated hazardous materials and hazardous waste, and potentially regulated waste (including but not limited to):

1. PCBs (transformers, capacitors, electrical cable, insulation, felt gaskets, thermal and acoustic insulation materials, adhesives, aluminized paint, various rubber and plastic products). Address procedures for each potential PCB application noted.

2. Asbestos - bulkhead and pipe or thermal insulation; bulkhead fire shields; electrical cable materials; brake linings; floor tiles and deck underlay; steam, water and vent flange gaskets; flexitalic gaskets; garlock seals; shaft packing; valve packing; pipe hanger inserts; and weld shop protectors, burn covers, blankets, and any fire fighting clothing or equipment.

3. Fuel oil, hydraulic oil, lubricants/greases/sludges, bilge water, and sump oil
4. Lead, Barium, Cadmium (paint, ballast)
5. Chromium (felt gaskets, sodium chromate fresh water, zinc chromate paint coatings)
6. Mercury (switches, gauges and indicators)
7. Ozone depleting substances (small appliances)
8. Waste water (contaminated during scrapping)
9. Degreasing agents
10. Paints to include enamels, polyurethanes, and water based latex paints.
11. Any caustics used for boilers and cleaning agents
12. Cadmium fasteners

B. Identify Environmental Protection Agency (EPA) identification (ID) numbers and all permits and licenses (Federal, State and local) required to perform this contract, and whether such have already been issued by the cognizant regulatory agency or will be obtained by the bidder or its subcontractors.

C. Identify names, addresses, EPA ID numbers of transporters, and disposal facilities. Provide temporary ID for storage permit and insurance for HM/HW storage. The bidder shall use only the transporters and treatment, storage, and disposal facilities (TSDFs) from the Qualified TSDFs List and Qualified transporters List (see IFB Article ST: USE OF TSDFs AND TRANSPORTERS for additional guidance). This list is available on the World Wide Web (www) at either <http://drms.dla.mil> or <http://drms.dla.mil/drmss/enviro.html>. Bidders who do not have access to the www may request a copy of these lists from the Sales Contracting Officer. (see IFB Article ST: USE OF TSDFs AND TRANSPORTERS for additional guidance). Submit documentation which demonstrates a working relationship with the transporters and facilities you intend to use. This documentation can include manifests, Letter of Intent, etc.

D. Provide a scrap site spill containment/prevention and emergency response plan. Describe measures to be taken to ensure that storm water drainage is not contaminated with hazardous materials remaining on or removed from ship(s).

E. Describe whether you, your company (any and all companies in which you have been a principal) or any subcontractor, including but not limited to, proposed

transporters, treatment, storage and disposal facilities, have within the last five years, received from any Federal, State, or local regulatory agency, to include, but not limited to, environmental (CERCLA, RCRA, and TSCA) or safety (OSHA): a) notices of violation(s); b) fines, c) convictions, or d) present or pending citations? Please provide evidence of final resolution of these actions.

2. OPERATIONAL PLAN: Provide a description of the technical approach planned which shows capability to accomplish removal, demilitarization, abatement, ship dismantling, towing, scrapping, scrap metal handling, and the quality assurance practices planned to ensure compliance with all Federal, State, and local laws and regulations. The technical approach should additionally address the following relative to all work performed under this contract:

- A. Towing operations and Plans. Describe how ships will be towed to ensure safe transport of ship to shipbreaking location.
- B. Provide step by step procedures to be followed when performing ship dismantling:
 - (1) Plans for using dry-dock, slip or other method
 - (2) Measures to ensure stability during hull dismantling
 - (3) Final dismantlement of underwater hull
 - (4) Measures to prevent flooding/sinking of the ship
 - (5) Measures to prevent slag or other contaminants from entering the water

The operational procedures should be in sufficient detail to demonstrate the bidder's ability to meet the timeframes in the contract under Article SJ, subparagraphs 3 and 4 and to demonstrate the bidder's understanding of the scope of the work effort required and the degree of difficulty involved.

- C. Provide a schedule for each ship identified in the proposal showing the progressive order in which the bidder proposes to execute the abatement and dismantling work, to include:
 - (1) Removal of the ship(s)
 - (2) Demilitarization of military equipment identified in the Invitation for Bid item description

- (3) Stripping Government property as provided in the Invitation for Bid item description
- (4) Planned completion dates and timeline for each phase of scrapping
- (5) Identify which work items are considered on the critical path to completion of the contract

D. Describe the planned arrangement of facilities to accommodate the flow of hazardous material abatement and complete dismantling to include:

- (1) Production flow of recyclable materials
- (2) Provide layout/arrangement (drawings, plat) of facilities to be used

E. Describe how you propose to monitor the work of all subcontractors to include subcontractors performing hazardous material removal and disposal, and shipbreaking.

F. For those positions requiring training/certification, provide copies of training records/certifications (competent person, abatement personnel, etc.). Provide documentation on the bidder's training program sufficient to demonstrate compliance with:

- (1) Resource Conservation and Recovery Act (RCRA)
- (2) Toxic Substances Control Act (TSCA)
- (3) Department of Transportation (DOT) Administration's
- (4) Hazardous communication standard
- (5) Occupational Safety and Health Act
- (6) Specific work to be performed

G. Describe procedures for securing ships for severe weather (e.g., hurricanes/storms) for all ships, including those temporarily moored pending commencement of dismantling work.

H. Describe the procedures for removing bilge and sump water.

I. Describe procedures to be used in removing fuel and hydraulic oil residue prior to cutting.

3. BUSINESS AND MANAGEMENT PLAN: Provide a description of the firm's management and organization. The proposal shall demonstrate that the corporate and project organization supports the level of effort, environmental, safety and health compliance, and dismantling procedures required for the proposed contract. The bidder must provide itemized cost projections for contract work requirements for Government review to ensure the bidder understands the scope and difficulty of the requirement of the contract.

A. The bidder shall identify and describe his, and all subcontractor's to be used, organizations to manage the scrapping contract including:

- (1) Services to be provided by subcontractors
- (2) Relationship of project organization to other company management structure to include:
 - a. corporate management;
 - b. responsibilities of the project organization and its authority to commit corporate resources to overcome obstacles; and
 - c. level of control of major subcontractors.
- (3) Identify the bidder's primary point of contact for addressing or resolving issues related to the contract.

B. Provide names and resumes of all key personnel of corporation and subcontractors including environmental and site safety program managers who will be involved with the ship scrapping under this RFTP (including period of employment with the company and/or prior employment) and major assistants. Include experience on similar projects.

C. Discuss risk factors which are involved in successfully completing this contract as related to contract requirements, including cutting and scrapping schedule and financial responsibility, and hazardous property abatement and disposal.

D. Provide a cost projection, which demonstrates an understanding of the scope of work, with regard to each of the following contract operations:

- (1) Towing
- (2) Hazardous material abatement and disposal
- (3) All direct costs associated with shipbreaking including labor, equipment and supplies

- (4) Hazardous waste sampling and disposal
 - (5) All other labor costs, including project administration and oversight
 - (6) Laboratory analysis of samples taken due to unknown constituents.
- E. Provide evidence that the necessary capital is available to cover projected costs (this may be a letter of commitment; the cost projection must be itemized)
- F. Identify the location where shipbreaking is to be conducted, and other information, to include:
- (1) How the ship will be transferred from the Government's facility to the location where shipbreaking is to be conducted.
 - (2) Describe the facilities to be utilized, including available space for mooring ships, piers, dry-docks, and/or marine rails and/or slips, and other industrial equipment
 - (3) Describe the characteristics of the facility such as water depth, accessibility; capacity, and any maintenance or dredging requirements.
 - (4) Describe the layout of the proposed facilities and the proposed mooring plan.
 - (5) Provide evidence of availability of such facilities for the duration of the contract performance, either by ownership, existing lease, or by letter from the facility owners indicating a statement of intent to utilize such facilities for shipbreaking
 - (6) Provide evidence that utilization of any leased facilities, if applicable, allow for shipbreaking operations and that shipbreaking operations are in conformance with local zoning regulations.
 - (7) Identify the past use of the property.
 - (8) Describe the past environmental compliance record of the facility.
 - (9) Describe security procedures for ship(s) during nonduty hours.

G. Provide the name, address, phone number, contract number (if applicable) and a brief description of the services, of either commercial concerns or Government agencies, for which prior comparable services have been rendered. Either the experience of the bidder or key individuals who will be active on this contract must be submitted.

4. SAFETY AND HEALTH PLAN:

A. Provide plan for compliance with safety procedures required by OSHA 29 CFR Part 1910 and 29 CFR Part 1915, including, but not limited to:

(1) Diving Operations. Describe diving program and services to be employed, if any, during ship breaking operations.

(2) Confined and Enclosed Spaces. Provide procedures for working in dangerous atmospheres, hot work, permits, gas free certificates, 10 percent PEL, marine chemist's, competent person, testing, respiratory protection, training, hazards, rescue, explosive proof equipment and ventilation.

(3) Welding, cutting and heating. Describe procedures for ventilation, personnel monitoring for lead, cadmium, mercury or beryllium, protection of personnel, training, respiratory protection, torch cutting, permits and inspections.

(4) Fire Prevention/Protection. Describe procedures for fire watch, hazards, fire extinguishers, hose lines, water supply, fire fighting equipment, training, proper handling and storage procedures, and identification of potential ignition sources.

(5) Compressed Gas Cylinders. Describe procedures for transporting, moving, securing and storing, use of hoses and torches.

(6) Scaffolds, Ladders, Other Working Surfaces. Describe use of personal flotation devices, guarding deck openings and edges, platforms, personal fall arrest systems, guardrails and access to ships.

(7) Housekeeping and Temporary Lighting. Provide procedures for work areas, including aisles, passageways and temporary flooring openings.

(8) Health and Sanitation. Describe washing facilities, showers, eating and smoking areas to be used and toilet facilities and change rooms.

(9) Hazard Communication (chemicals). Describe procedures for providing information to employees, labeling, material data safety sheets (MSDS), employee training, non-routine tasks, multi-employer workplaces, hazards of chemicals; lead, asbestos, cadmium, etc.

(10) Asbestos Abatement Program. Requirements: PEL 0.1 f/cc, excursion limit 1.0 f/cc. Describe multi-employer worksites, regulated areas, qualified person, exposure assessments and monitoring, periodic monitoring, engineering controls and work practices, ventilation, prohibitions, barriers, negative pressure enclosure, glove bag, PPE, laundering, decontamination areas, lunch areas, warning signs, labels, housekeeping, medical surveillance, recordkeeping, inspections, employee information and training.

(11) Gear and Equipment for Rigging and material handling. Describe procedures for testing and inspection of ropes, chains and slings, shackles and hooks, chain falls and pull-lifts, hoisting and hauling equipment and qualification of operators.

(12) Personal Protective Equipment. Provide certifications, eye and noise protection, protection against radiant energy, protection in atmospheres immediately dangerous to life, protection against gaseous and particulate contaminants, head, foot and body protection, personal, personal fall arrest systems, life rings, etc. Describe respirator protection program and hearing conservation program.

(13) Employee Emergency Plans. Describe emergency escape routes, procedures to account for employees during evacuations, alarm systems, weather plan, rescue, medical duties and first aid procedures, treatment of injured personnel, emergency numbers and training.

(14) Lead Abatement Program. Requirement: Action level 30 ug/m³, PEL 50 ug/m³. Describe procedures to used in work operations to provide ventilation, use hygiene facilities and practices, showers change rooms, warning signs, medical surveillance, biological monitoring,

exposure monitoring, testing, work clothing, training, etc.

(15) Spill Containment Program and Emergency Response Plan. Describe operating procedures, medical surveillance, clean up activities, PPE and emergency equipment, health hazards, handling, transporting, labeling and disposing of container, site security and control, response procedures, overall responsibilities, training, etc.

Late Submissions and Modifications of Technical Proposals Under Two-Step Formal Advertising

A. Technical proposals and modifications thereof must be in the possession of the Sales Contracting Officer by 4:30 p.m. Eastern time on April 30, 1998. Any technical proposals or modifications thereof received after 4:30 p.m. Eastern time on April 30, 1998 will not be considered.

B. The only acceptable evidence to establish the time of receipt by the Government is the time/date stamp at the Defense Reutilization and Marketing Service (DRMS) National Sales Office.

EVALUATION CRITERIA

A. The evaluation of each technical factor will consider completeness and clarity, degree of compliance with the solicitation, and the risk that the approach provided will be completely successful as proposed. The following technical factors are considered to be of equal importance:

Environmental Compliance Plan

Operational Plan

Business and Management Plan

Safety and Health Plan

B. Each factor will be rated as acceptable, reasonably susceptible to being made acceptable, or unacceptable. The introduction and any supplementary information provided will be evaluated only in conjunction with the whole technical proposal and only to the extent that they support the individual evaluation factors discussed above. A proposal will not be acceptable unless it is determined acceptable for all factors. If a proposal contains a significant deficiency for a factor, it will not be considered acceptable for that specific factor. A deficiency is defined as that part of an bidder's proposal which

would not satisfy the Government's requirements. Acceptability of each proposal will be based upon (1) compliance with the requirements of the foregoing paragraphs of this Enclosure 1 concerning content of the technical proposal and (2) evaluation of the reasonable likelihood that the proposed plans will meet the contract requirements and objectives.

ORAL OR WRITTEN DISCUSSIONS:

The Government intends to evaluate technical proposals and issue the Invitation for Bid (IFB) without discussions with bidders (except communications conducted for the purpose of minor clarification). Therefore, each initial technical proposal should contain the bidder's best terms from a technical standpoint. However, the Government reserves the right to conduct discussions if later determined by the Sales Contracting Officer to be necessary.

NOTIFICATION OF UNACCEPTABLE PROPOSALS:

When a technical proposal is rated unacceptable (either initially or after clarification/discussions), the Sales Contracting Officer will promptly notify the bidder of the basis of the determination and that a revision of the proposal will not be considered. Upon written request and as soon as practical after award, the Sales Contracting Officer will debrief unsuccessful bidders.

MAIL YOUR TECHNICAL PROPOSAL (plus 4 copies) TO:

Defense Reutilization and Marketing Service
Attn: Ms. Wendy Jones
Sales Division, DRMS-LMIB
74 Washington Avenue North
Battle Creek, MI 49017

PROVIDED FOR INFORMATION ONLY.

THE INFORMATION CONTAINED IN THIS ENCLOSURE IS INTENDED TO BE INCLUDED IN THE PROPOSED INVITATION FOR BIDS (IFB) SALES CATALOG, TO BE ISSUED AS STEP TWO OF THIS TWO-STEP SOLICITATION. ANY VARIANCES FROM THIS ENCLOSURE WILL BE HIGHLIGHTED IN THE IFB SALES CATALOG ISSUED IN STEP TWO.

IF AN IFB IS ISSUED IN STEP TWO, THE IFB WILL ONLY BE ISSUED TO BIDDERS WHO HAVE SUBMITTED AN ACCEPTABLE TECHNICAL PROPOSAL IN STEP ONE OF THIS SOLICITATION UNDER RFTP 31-8018.

| | <u>PAGE</u> |
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| ITEM DESCRIPTIONS | 15-32 |
| ENVIRONMENTAL & SAFETY INFORMATION INSTRUCTIONS AND TERMS AND CONDITIONS | 33-35 |
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| ITEM BID AND AWARD PAGE..... | |
| END USE CERTIFICATE..... | |
| STATEMENT OF INTENT..... | |

PAYMENTS: All Payments must be made in U.S. Currency in the form of cash, cashier's check, certified check, Traveler's check, bank draft or money order or credit card (Mastercard or Visa only) and submitted directly to the National Sales Office.

MAIL TO: DEFENSE REUTILIZATION AND MARKETING SERVICE
NATIONAL SALES OFFICE (DRMS-LMIB)
74 N. WASHINGTON
BATTLE CREEK, MI. 49017-3092

OR FAX: 616-961-7568

**ITEMS 1-6 ARE BEING SOLD IN A PREDETERMINED LOT
ITEMS 7- 12 ARE BEING SOLD IN A PREDETERMINED LOT**

ITEM 13 IS BEING SOLD AS AN INDIVIDUAL ITEM

INDIVIDUAL BIDS WILL NOT BE ACCEPTED ON ITEMS BEING SOLD IN PREDETERMINED LOTS. INDIVIDUAL BIDS WILL BE ACCEPTED ON ITEM 13 ONLY.

CONTRACT AWARD WILL BE BASED ON THE PRICE SUBMITTED FOR EACH LOT. HOWEVER, FOR TRACKING PURPOSES IN THE DRMS AUTOMATED SALES PROGRAM, PLEASE PROVIDE PRICES FOR EACH ITEM IN EACH LOT.

LOT 1, ITEMS 1-6, ARE LOCATED AT SUISUN BAY RESERVE FLEET
 BENECIA, CA 94510
 LOT 2, ITEMS 7-10, ARE LOCATED AT SUISUN BAY RESERVE FLEET
 BENECIA, CA 94510
 LOT 2, ITEMS 11 AND 12, ARE LOCATED AT NISMF PEARL HARBOR, HI
 WAIPAHU, HI 96797-3272
 ITEM 13, IS LOCATED AT MARE ISLAND, VALLEJO, CA 94590, BUT
 MAY BE MOVED ELSEWHERE IN THE SAN FRANCISCO BAY AREA
 PRIOR TO CONTRACT AWARD

INDIVIDUAL BIDS WILL NOT BE ACCEPTED ON ITEMS SOLD IN LOTS.
 INDIVIDUAL BIDS WILL BE ACCEPTED ON ITEM 13 ONLY.

Ships are available for inspection by appointment only Monday through Friday, excluding holidays, between the hours of 0800 - 1500. Appointment must be made 7 days in advance. Please submit a fax on company letterhead providing the name, social security, employer, and vehicle description for each individual inspecting these ships. Fax to (360)476-8665 for ships at Suisun Bay and Mare Island and (808)471-4524 for ships at Pearl Harbor.

THE GOVERNMENT DOES NOT WARRANT OR GUARANTEE, BY EXPRESSION OR IMPLICATION, THE SIZE, TONNAGE, OR OTHER DESCRIPTIONS OF THE SHIPS.

LOT 1

1. GUIDED MISSILE CRUISER, EX-JOUETT, CG-29:

BUILT 1964 BY PUGET SOUND NAVAL SHIPYARD. STEEL HULL WITH ALUMINUM SUPERSTRUCTURE

CHARACTERISTICS

| | |
|---------------------|------------------------|
| Length | 547' |
| Beam..... | 54' 8" |
| Draft..... | fwd.....13' 6" |
| | mid.....16' |
| | aft.....19' |
| Main Engines...2... | Geared Turbine Delaval |
| Boilers...4... | Combustion Engineering |

THERE HAS BEEN EXTENSIVE STRIPPING AND REMOVAL OF EQUIPMENT IN ALL AREAS OF THE SHIP. THE SHIP HAS BEEN SUBJECTED TO PRECIOUS METALS RECOVERY.

It is the opinion of the Government that the hull is in good condition.

Displacement tons: ESTIMATED 6,375 TONS - BASED ON WATERLINE SURVEY

Each bidder must inspect the ship.

MAJOR ITEMS OF EQUIPMENT REMAINING ON BOARD THE SHIP:

| <u>Industrial Plant Equipment</u> | <u>Location</u> |
|-----------------------------------|-----------------|
| 1. Lablond Lathe 54" | 2-152-0-Q |
| 2. Power Hacksaw 17" | " |
| 3. Pedestal Grinder 10" | 2-152-0-Q |
| 4. Electro Drill Press Model 801C | " |
| 5. Wilson Model 37G 60 Ton Press | " |

Other Equipment and Material

| | |
|-----------------------------------|-----------|
| 1. Galley Equipment | 1-92-0-L |
| 2. Miller 400SS Welder | 1-35-5-L |
| 3. Miller 300SS Welder | 1-72-2-L |
| 4. Linde 301 HW Welder | 2-152-0-Q |
| 5. Universal Sand Blaster Mod B-3 | " |

The Main Anchor and chain are not included as part of the ship sale.

This ship must be scrapped to the extent specified in Article SJ.

DEMIL CODE: D

DEMILITARIZATION: Keypoint demilitarization was previously completed so as to preclude restoration or repair to a usable condition. All guided missile launching systems, mounts and fire control systems; sonar domes, transducers and associated equipment; torpedo tubes, gun mounts and any other weapon systems must be further and totally destroyed by melting, cutting, tearing, scratching, crushing or breaking the item and components.

CONTACT: PETE GALASSI PHONE (360)476-3510

LOCATION: SUISUN BAY RESERVE FLEET, BENECIA, CA

1 EACH

END USE CERTIFICATE AND STATEMENT OF INTENT APPLIES AND MUST BE COMPLETED AND SUBMITTED WITH BIDS FOR THIS ITEM.

2. GUIDED MISSILE CRUISER, EX-HORNE, CG-30:

**BUILT BY SAN FRANCISCO NAVAL SHIPYARD, COMPLETED OCTOBER 1964.
STEEL HULL WITH ALUMINUM SUPERSTRUCTURE**

CHARACTERISTICS

Length.....547' 0"
 Beam.....54' 8"
 Draft.....fwd.....10' 6"
 mid.....14' 0"
 aft.....18' 6"
 Main Engines... 2... Geared Turbine Delaval

Boilers... 4... Combustion Engineering

THERE HAS BEEN EXTENSIVE STRIPPING AND REMOVAL OF EQUIPMENT IN ALL AREAS OF THE SHIP. THE SHIP HAS BEEN SUBJECTED TO PRECIOUS METALS RECOVERY.

It is the opinion of the Government that the hull is in fair condition.

Displacement tons: ESTIMATED 6,305 TONS - BASED ON WATERLINE SURVEY

Each bidder must inspect the ship.

MAJOR ITEMS OF EQUIPMENT REMAINING ON BOARD THE SHIP:

Machine Shop

- 1. 1 ea. - Lathe
- 2. 1 ea. - Drill
- 3. 1 ea. - Milling Machine
- 4. 1 ea. - Grinder

The Main Anchor and chain are not included as part of the ship sale.

This ship must be scrapped to the extent specified in Article SJ.

DEMIL CODE: D

DEMILITARIZATION: Keypoint demilitarization was previously completed so as to preclude restoration or repair to a usable condition. All guided missile launching systems, mounts and fire control systems; sonar domes, transducers and associated equipment; torpedo tubes, gun mounts and any other weapon systems must be further and totally destroyed by melting, cutting, tearing, scratching, crushing or breaking the item and components.

CONTACT: PETE GALASSI PHONE (360)476-3510

LOCATION: SUISUN BAY RESERVE FLEET, BENECIA, CA

1 EACH

END USE CERTIFICATE AND STATEMENT OF INTENT APPLIES AND MUST BE COMPLETED AND SUBMITTED WITH BIDS FOR THIS ITEM.

3. GUIDED MISSILE CRUISER, EX-STERRETT, CG-31:

BUILT BY PUGET SOUND NAVAL SHIPYARD, COMPLETED JUNE 1964, STEEL HULL WITH ALUMINUM SUPERSTRUCTURE

CHARACTERISTICS

Length.....547' 0"

Beam.....54' 8"
 Draft.....fwd.....11' 0"
 mid.....14' 6"
 aft.....18'
 Main Engines... 2... Geared Turbine Delaval
 Boilers... 4... Combustion Engineering

THERE HAS BEEN EXTENSIVE STRIPPING AND REMOVAL OF EQUIPMENT IN ALL AREAS OF THE SHIP. THE SHIP HAS BEEN SUBJECTED TO PRECIOUS METALS RECOVERY.

It is the opinion of the Government that the hull is in good condition.

Displacement tons: ESTIMATED 6,206 TONS (BASED ON WATERLINE SURVEY)

Each bidder must inspect the ship.

MAJOR ITEMS OF EQUIPMENT REMAINING ON BOARD THE SHIP:

| <u>Industrial Plant Equipment</u> | <u>Location</u> |
|-----------------------------------|-----------------|
| 1. Buffalo N18 Drill | 2-152-0-Q |
| 2. K.R. Wilson 60 Ton Press | " |
| 3. Lablond 4' X 30" Lathe | " |

Other Equipment and Material

- | | |
|--------------------------|----------|
| 1. Miller Welder SRH-333 | 1-35-5-L |
|--------------------------|----------|

The Main Anchor and chain and 6 each extra anchors are not included as part of the ship sale.

This ship must be scrapped to the extent specified in Article SJ.

DEMIL CODE: D

DEMILITARIZATION: Keypoint demilitarization was previously completed so as to preclude restoration or repair to a usable condition. All guided missile launching systems, mounts and fire control systems; sonar domes, transducers and associated equipment; torpedo tubes, gun mounts and any other weapon systems must be further and totally destroyed by melting, cutting, tearing, scratching, crushing or breaking the item and components.

CONTACT: PETE GALASSI PHONE (360)476-3510

LOCATION: SUISUN BAY RESERVE FLEET, BENECIA, CA

1 EACH

END USE CERTIFICATE AND STATEMENT OF INTENT APPLIES AND MUST BE COMPLETED AND SUBMITTED WITH BIDS FOR THIS ITEM.

4. GUIDED MISSILE CRUISER, EX-WILLIAM H. STANDLEY, CG-32:

BUILT BY BATH IRON WORKS CORPORATION, COMPLETED DECEMBER 1964,
 STEEL HULL WITH ALUMINUM SUPERSTRUCTURE

CHARACTERISTICS

Length.....547' 0"
 Beam.....54' 8"
 Draft.....fwd.....10' 0"
 mid.....14'
 aft.....18'
 Main Engines... 2... Geared Turbine Delaval
 Boilers... 4... Combustion Engineering

THERE HAS BEEN EXTENSIVE STRIPPING AND REMOVAL OF EQUIPMENT IN ALL
 AREAS OF THE SHIP. THE SHIP HAS BEEN SUBJECTED TO PRECIOUS METALS
 RECOVERY.

It is the opinion of the Government that the hull is in good condition.

Displacement tons: ESTIMATED 6,101 TONS (BASED ON WATERLINE SURVEY)

Each bidder must inspect the ship.

MAJOR ITEMS OF EQUIPMENT REMAINING ON BOARD THE SHIP:

| <u>Industrial Plant Equipment</u> | <u>Location</u> |
|-----------------------------------|-----------------|
| 1. Buffalo N18 Drill Press | 2-152-0-Q |
| 2. Sheetmetal Brack 4' | " |
| 3. Milling Mach Mod H | " |
| 4. Leblond 4 X 10" Lathe | " |
| 5. 10 Ton Hyd Press | " |

Other Equipment and Material

| | |
|---------------------|-----------|
| 1. Miller Welder | 2-152-0-Q |
| 2. Galley Equipment | 1-92-0-L |

The Main Anchor and chain are not included as part of the ship sale.

This ship must be scrapped to the extent specified in Article SJ.

DEMIL CODE: D

DEMILITARIZATION: Keypoint demilitarization was previously completed so as to preclude restoration or repair to a usable condition. All guided missile launching systems, mounts and fire control systems; sonar domes, transducers and associated equipment; torpedo tubes, gun mounts and any other weapon systems must be further and totally destroyed by melting, cutting, tearing, scratching, crushing or breaking the item and components.

CONTACT: PETE GALASSI PHONE (360)476-3510

LOCATION: SUISUN BAY RESERVE FLEET, BENECIA, CA

1 EACH

END USE CERTIFICATE AND STATEMENT OF INTENT APPLIES AND MUST BE COMPLETED AND SUBMITTED WITH BIDS FOR THIS ITEM.

5. GUIDED MISSILE CRUISER, EX-FOX, CG-33:

BUILT BY TODD SHIPYARD CORPORATION, COMPLETED NOVEMBER 1964,
STEEL HULL WITH ALUMINUM SUPERSTRUCTURE

CHARACTERISTICS

Length.....547' 0"
Beam.....54' 8"
Draft.....fwd.....10' 6"
 mid.....14' 0"
 aft.....17' 6"

Main Engines... 2... Geared Turbine Delaval
Boilers... 4... Combustion Engineering

THERE HAS BEEN EXTENSIVE STRIPPING AND REMOVAL OF EQUIPMENT IN ALL AREAS OF THE SHIP. THE SHIP HAS BEEN SUBJECTED TO PRECIOUS METALS RECOVERY.

It is the opinion of the Government that the hull is in good condition.

Displacement tons: ESTIMATED 6,312 TONS (BASED ON WATERLINE SURVEY)

Each bidder must inspect the ship.

MAJOR ITEMS OF EQUIPMENT REMAINING ON BOARD THE SHIP:

| <u>Industrial Plant Equipment</u> | <u>Location</u> |
|-----------------------------------|-----------------|
| 1. Buffalo N18 Drill Press | 2-152-0-Q |
| 2. Pexto Mod G-52 Dropshear | " |
| 3. U.S. Tool 10" Benchgrinder | " |
| 4. Leblond 4' X 10" Lathe | " |
| 5. Peerless 17" PWR Hacksaw | " |

Other Equipment and Material

| | |
|---------------------------------|-----------|
| 1. Miller Welder (2 ea) | 2-152-0-Q |
| 2. Galley Equipment | 1-92-0-L |
| 3. Dryrod 550 Degree F Rod Oven | 2-152-0-Q |
| 4. Miller Welder SRH-333 | 1-72-2-L |

The Main Anchor and chain are not included as part of the ship sale.

This ship must be scrapped to the extent specified in Article SJ.

DEMIL CODE: D

DEMILITARIZATION: Keypoint demilitarization was previously completed so as to preclude restoration or repair to a usable condition. All guided missile launching systems, mounts and fire control systems; sonar domes, transducers and associated equipment; torpedo tubes, mounts and any other weapon systems must be further and totally destroyed by melting, cutting, tearing, scratching, crushing or breaking the item and components.

CONTACT: PETE GALASSI PHONE (360)476-3510

LOCATION: SUISUN BAY RESERVE FLEET, BENECIA, CA

1 EACH

END USE CERTIFICATE AND STATEMENT OF INTENT APPLIES AND MUST BE COMPLETED AND SUBMITTED WITH BIDS FOR THIS ITEM.

6. SHIP, FRIGATE, EX-MEYERKORD, FF-1058

BUILT BY TODD SHIPYARDS, COMPLETED JULY 1966, STEEL HULL WITH ALUMINUM SUPERSTRUCTURE, ONE BRONZE PROPELLER

CHARACTERISTICS

| | |
|---------------------|-----------------------------------|
| Length..... | 438' 0" |
| Beam..... | 46' 0" |
| Draft..... | fwd.....10' 8" |
| | aft.....15' 8" |
| Main Engines...1... | Westinghouse |
| Boilers...2... | Babcox & Wilcox or Foster-Wheeler |

THERE HAS BEEN EXTENSIVE STRIPPING AND REMOVAL OF EQUIPMENT IN ALL AREAS OF THE SHIP. THE SHIP HAS BEEN SUBJECTED TO PRECIOUS METALS RECOVERY.

It is the opinion of the Government that the hull is in good condition.

DISPLACEMENT TONS: ESTIMATED 3,011 TONS (BASED ON WATERLINE SURVEY)

Each bidder must inspect the ship.

This ship must be scrapped to the extent specified in Article SJ.

DEMIL CODE: D

DEMILITARIZATION: Keypoint demilitarization was previously completed so as to preclude restoration or repair to a usable condition. All guided missile launching systems, mounts and fire control systems; sonar domes, transducers and associated equipment; torpedo tubes, gun mounts and

31-8018

any other weapon systems must be further and totally destroyed by melting, cutting, tearing, scratching, crushing or breaking the item and components.

CONTACT: PETE GALASSI PHONE (360)476-3510

LOCATION: SUISUN BAY RESERVE FLEET, BENECIA, CA

1 EACH

THE SHIPS ANCHOR AND CHAIN ARE NOT INCLUDED IN SALE. SHORE POWER SWITCHBOXES AND THE FLOOD ALARM SYSTEM ARE NOT INCLUDED IN THE SALE.

END USE CERTIFICATE AND STATEMENT OF INTENT APPLIES AND MUST BE COMPLETED AND SUBMITTED WITH BIDS FOR THIS ITEM.

LOT 2

7. GUIDED MISSILE CRUISER, EX-HALSEY, CG-23:

**BUILT BY SAN FRANCISCO NAVAL SHIPYARD, COMPLETED JANUARY 1962,
STEEL HULL WITH ALUMINUM SUPERSTRUCTURE**

CHARACTERISTICS

Length.....533' 0"
Beam.....54' 9"
Draft.....fwd.....12' 0"
 mid.....15' 6"
 aft.....19' 0"
Main Engines...2... Allis Chalmers
Boilers...4...Combustion Engineering

THERE HAS BEEN EXTENSIVE STRIPPING AND REMOVAL OF EQUIPMENT IN ALL AREAS OF THE SHIP. THE SHIP HAS BEEN SUBJECTED TO PRECIOUS METALS RECOVERY.

It is the opinion of the Government that the hull is in good condition.

Displacement tons: ESTIMATED 5,985 TONS (BASED ON WATERLINE SURVEY)

Each bidder must inspect the ship.

MAJOR ITEMS OF EQUIPMENT REMAINING ON BOARD THE SHIP:

| <u>Industrial Plant Equipment</u> | <u>Location</u> |
|-----------------------------------|-----------------|
| 1. Shipley Lathe 14" | 1-73-3-Q |
| 2. Buffalo Mod 18 Drill Press | " |

Other Equipment and Material

| | |
|---------------------|----------|
| 1. Galley Equipment | 1-92-0-L |
|---------------------|----------|

The Main Anchor and chain are not included as part of the ship sale.

This ship must be scrapped to the extent specified in Article SJ.

DEMIL CODE: D

DEMILITARIZATION: Keypoint demilitarization was previously completed so as to preclude restoration or repair to a usable condition. All guided missile launching systems, mounts and fire control systems; sonar domes, transducers and associated equipment; torpedo tubes, ASROC launchers and any other weapon systems must be further and totally destroyed by melting, cutting, tearing, scratching, crushing or breaking the item and components.

CONTACT: PETE GALASSI PHONE (360)476-3510

LOCATION: SUISUN BAY RESERVE FLEET, BENECIA, CA

1 EACH

END USE CERTIFICATE AND STATEMENT OF INTENT APPLIES AND MUST BE COMPLETED AND SUBMITTED WITH BIDS FOR THIS ITEM.

8. GUIDED MISSILE CRUISER, EX-LEAHY, CG-16:

BUILT BY BATH IRON WORKS CORPORATION, COMPLETED JULY 1961, STEEL HULL WITH ALUMINUM SUPERSTRUCTURE

CHARACTERISTICS

Length.....533' 0"
 Beam.....54' 9"
 Draft.....fwd.....12' 6"
 mid.....16' 0"
 aft.....20' 0"
 Main Engines...2... General Electric
 Boilers...4...Babcox & Wilcox

THERE HAS BEEN EXTENSIVE STRIPPING AND REMOVAL OF EQUIPMENT IN ALL AREAS OF THE SHIP. THE SHIP HAS BEEN SUBJECTED TO PRECIOUS METALS RECOVERY.

It is the opinion of the Government that the hull is in good condition.

Displacement tons: ESTIMATED 4,650 TONS (BASED ON WATERLINE SURVEY)

Each bidder must inspect the ship.

MAJOR ITEMS OF EQUIPMENT REMAINING ON BOARD THE SHIP:

| <u>Industrial Plant Equipment</u> | <u>Location</u> |
|-----------------------------------|-----------------|
| 1. Clausan 17" Lathe | 1-73-3-Q |

Other Equipment and Material

| | |
|------------------------------|----------|
| 1. Saturn T-1000 Gas Turbine | 1-20-0-E |
|------------------------------|----------|

The Main Anchor and chain, 3 ea. 14500# anchors (01-166-0), 7 ea. 13000# anchors (fantail), and 3 ea. 16000# anchors (bow) are not included as part of the ship sale.

This ship must be scrapped to the extent specified in Article SJ.

DEMIL CODE: D

DEMILITARIZATION: Keypoint demilitarization was previously completed so as to preclude restoration or repair to a usable condition. All guided missile launching systems, mounts and fire control systems; sonar domes, transducers and associated equipment; torpedo tubes, ASROC

launchers and any other weapon systems must be further and totally destroyed by melting, cutting, tearing, scratching, crushing or breaking the item and components.

CONTACT: PETE GALASSI PHONE (360)476-3510

LOCATION: SUISUN BAY RESERVE FLEET, BENECIA, CA

1 EACH

END USE CERTIFICATE AND STATEMENT OF INTENT APPLIES AND MUST BE COMPLETED AND SUBMITTED WITH BIDS FOR THIS ITEM.

9. GUIDED MISSILE CRUISER, EX-ENGLAND, CG-22:

BUILT BY TODD SHIPYARD CORPORATION, COMPLETED MARCH 1962, STEEL HULL WITH ALUMINUM SUPERSTRUCTURE

CHARACTERISTICS

Length.....533' 0"
 Beam.....54' 9"
 Draft.....fwd.....10' 0"
 mid.....14' 3"
 aft.....18' 6"
 Main Engines...2... Delaval
 Boilers...4...Combustion Engineering

THERE HAS BEEN EXTENSIVE STRIPPING AND REMOVAL OF EQUIPMENT IN ALL AREAS OF THE SHIP. THE SHIP HAS BEEN SUBJECTED TO PRECIOUS METALS RECOVERY.

It is the opinion of the Government that the hull is in good condition.

Displacement tons: ESTIMATED 6,023 TONS (BASED ON WATERLINE SURVEY)

Each bidder must inspect the ship.

MAJOR ITEMS OF EQUIPMENT REMAINING ON BOARD THE SHIP:

| <u>Industrial Plant Equipment</u> | <u>Location</u> |
|-----------------------------------|-----------------|
| 1. Clausing Lathe 17" X 5' | 2-72-3-Q |

Other Equipment and Material

| | |
|-------------------------------|-----------|
| 1. Miller Welder | 2-72-3-Q |
| 2. Galley Equipment | 1-92-0-L |
| 3. Saturn T-1000 Gas Turbine | 1-20-0-E |
| 4. Cissell 50lb Dryers (2 ea) | 2-194-0-Q |
| 5. Forenta Presses (3 ea) | " |
| 6. Dynawash Mod PNSWE | " |

The Main Anchor and chain, ribbon boards (exterior bridge P/S), and 3 ea. Yokohama 32x50 fenders (01-158-0-A) are not included as part of the ship sale.

This ship must be scrapped to the extent specified in Article SJ.

DEMIL CODE: D

DEMILITARIZATION: Keypoint demilitarization was previously completed so as to preclude restoration or repair to a usable condition. All guided missile launching systems, mounts and fire control systems; sonar domes, transducers and associated equipment; torpedo tubes, ASROC launchers and any other weapon systems must be further and totally destroyed by melting, cutting, tearing, scratching, crushing or breaking the item and components.

CONTACT: PETE GALASSI PHONE (360)476-3510

LOCATION: SUISUN BAY RESERVE FLEET, BENECIA, CA

1 EACH

END USE CERTIFICATE AND STATEMENT OF INTENT APPLIES AND MUST BE COMPLETED AND SUBMITTED WITH BIDS FOR THIS ITEM.

10. GUIDED MISSILE CRUISER, EX-GRIDLEY, CG-21:

BUILT BY PUGET SOUND BRIDGE & DRY DOCK COMPANY, COMPLETED JULY 1961, STEEL HULL WITH ALUMINUM SUPERSTRUCTURE

CHARACTERISTICS

| | |
|---------------------|------------------------|
| Length..... | 533' 0" |
| Beam..... | 54' 9" |
| Draft..... | fwd.....12' 0" |
| | mid.....15' 6" |
| | aft.....19' 0" |
| Main Engines...2... | Delaval |
| Boilers...4... | Combustion Engineering |

THERE HAS BEEN EXTENSIVE STRIPPING AND REMOVAL OF EQUIPMENT IN ALL AREAS OF THE SHIP. THE SHIP HAS BEEN SUBJECTED TO PRECIOUS METALS RECOVERY.

It is the opinion of the Government that the hull is in good condition.

Displacement tons: ESTIMATED 4,650 TONS (BASED ON WATERLINE SURVEY)

Each bidder must inspect the ship.

MAJOR ITEMS OF EQUIPMENT REMAINING ON BOARD THE SHIP:

| <u>Industrial Plant Equipment</u> | <u>Location</u> |
|-----------------------------------|-----------------|
| 1. Leblond Regal Mod 13C Lathe | 1-72-3-Q |

- 2. Bridgeport Mod 12 Brt Mill Mach “
- 3. Dale Arbor Press “
- 4. Buffalo Mod 18 Drill Press “
- 5. Benchgrinder 10” “

Other Equipment and Material

- 1. Miller Welder 1-72-3-Q
- 2. Galley Equipment 1-92-0-L
- 3. Saturn T-1000 Gas Turbine 1-20-0-E
- 4. Cissell 50lb Dryers (2 ea) 2-194-0-Q
- 5. Forenta Presses (3 ea) “
- 6. Dynawash Mod PNSWE “

The Main Anchor and chain, ribbon boards (exterior bridge P/S), 5 ea. 13000# anchors (fantail), and 2 ea. 20000# anchors (fantail) are not included as part of the ship sale.

This ship must be scrapped to the extent specified in Article SJ.

DEMILITARIZATION: Keypoint demilitarization was previously completed so as to preclude restoration or repair to a usable condition. All guided missile launching systems, mounts and fire control systems; sonar domes, transducers and associated equipment; torpedo tubes, ASROC launchers and any other weapon systems must be further and totally destroyed by melting, cutting, tearing, scratching, crushing or breaking the item and components.

DEMIL CODE: D

CONTACT: PETE GALASSI PHONE (360)476-3510

LOCATION: SUISUN BAY RESERVE FLEET, BENECIA, CA

1 EACH

END USE CERTIFICATE AND STATEMENT OF INTENT APPLIES AND MUST BE COMPLETED AND SUBMITTED WITH BIDS FOR THIS ITEM.

11. GUIDED MISSILE CRUISER, EX-REEVES, CG-24:

BUILT BY PUGET SOUND NAVAL SHIPYARD, COMPLETED MAY 1962, STEEL HULL WITH ALUMINUM SUPERSTRUCTURE

CHARACTERISTICS

Length.....533' 0"
 Beam.....54' 9"
 Draft.....fwd.....14' 2"
 aft.....16' 9"
 Main Engines... 2... Geared Turbines, Allis Chalmers
 Boilers... 4... Foster Wheeler

THERE HAS BEEN EXTENSIVE STRIPPING AND REMOVAL OF EQUIPMENT IN ALL AREAS OF THE SHIP. THE SHIP HAS BEEN SUBJECTED TO PRECIOUS METALS RECOVERY.

It is the opinion of the Government that the hull is in fair condition.

Displacement tons: ESTIMATED 5,611 TONS (BASED ON WATERLINE SURVEY)

Each bidder must inspect the ship.

MAJOR ITEMS OF EQUIPMENT REMAINING ON BOARD THE SHIP:

Industrial Plant Equipment

1. Hydraulic Press
2. Milling Mach
3. Grinder

Other Equipment and Material

1. (4) Steam Presses
2. (2) Washers
3. (3) Dryers

The Main Anchor and chain, fire and flooding alarm system, fenders, chains, wire and mooring lines are not included as part of the ship sale.

This ship must be scrapped to the extent specified in Article SJ.

DEMIL CODE: D

DEMILITARIZATION: Keypoint demilitarization was previously completed so as to preclude restoration or repair to a usable condition. All guided missile launching systems, mounts and fire control systems; sonar domes, transducers and associated equipment; torpedo tubes, ASROC launchers and any other weapon systems must be further and totally destroyed by melting, cutting, tearing, scratching, crushing or breaking the item and components.

CONTACT: WALT LEONARD, PHONE (808)471-4521

LOCATION: NISMF PEARL HARBOR, WAIPAHU, HI 96797-3272

1 EACH

END USE CERTIFICATE AND STATEMENT OF INTENT APPLIES AND MUST BE COMPLETED AND SUBMITTED WITH BIDS FOR THIS ITEM.

12. GUIDED MISSILE CRUISER, EX-WORDEN, CG-18:

BUILT BY BATH IRON WORKS CORPORATION, COMPLETED JUNE 1962, STEEL HULL WITH ALUMINUM SUPERSTRUCTURE

CHARACTERISTICS

END USE CERTIFICATE AND STATEMENT OF INTENT APPLIES AND MUST BE COMPLETED AND SUBMITTED WITH BIDS FOR THIS ITEM.

INDIVIDUAL ITEM

13. AIRCRAFT, CARRIER, EX-ORISKANY, CVA-34:

BUILT BY NEW YORK NAVY YARD, COMPLETED OCTOBER 1945, STEEL HULL

CHARACTERISTICS

Length Overall.....910' 7"
 Length between perpendiculars.....820' 0"
 Frame Spacing.....4' 0"
 Projection FWD of FWD Perpendiculars.....50' 8"
 Projection AFT of AFT Perpendiculars.....40' 1"
 Breadth Extreme Flight Deck193' 0"
 Breadth, molded, Main Deck (Mid-Perp)....160' 7"
 Breadth Extreme Main Deck (Fr. 115,150)..142' 9"
 Depth, Molded, Main Deck.....54' 8"
 Depth, Molded, Forecastle Deck.....63' 1"
 Draft Forward.....21' 3"
 Draft Aft.....26' 3"
 Height (highest point on ship).....132' 0"
 Length, Vertical Keel.....664' 0"
 Length, Beam Ratio.....7.73

THERE HAS BEEN EXTENSIVE STRIPPING AND REMOVAL OF EQUIPMENT IN ALL AREAS OF THE SHIP. THE SHIP HAS BEEN SUBJECTED TO PRECIOUS METALS RECOVERY.

It is the opinion of the Government that the hull is in fair condition.

Displacement tons: ESTIMATED 31,850 TONS (BASED ON WATERLINE SURVEY)

Each bidder must inspect the ship.

MAJOR ITEMS OF EQUIPMENT REMAINING ON BOARD THE SHIP:

4 ea. Turbines, Main Propulsion, high pressure, Westinghouse
 4 ea. Turbines, Main Propulsion, low pressure, Westinghouse
 4 ea. Gear, Reduction, Main Propulsion, Westinghouse
 4 ea. Propellers/Shafts, Main Propulsion
 8 ea. Boilers, Babcox and Wilcox
 16 ea. Blower, Force draft
 4 ea. Condensers, main
 2 ea. Deaireating tank
 4 ea. Condenser, auxiliary
 3 ea. Generator, Ship service, 1700 KW A/C
 5 ea. Pump, Condensate

3 ea. Pump, Circulating
 7 ea. Pump, Fire and Flushing
 5 ea. Pump, Main Feed, Steam
 4 ea. Pump, Main Fuel
 4 ea. Pump, Main Fuel Oil Boster, Steam
 4 ea. Pump, Lube Oil, Steam
 2 ea. Pump, Saltwater, Electric
 3 ea. Pump, Brine
 1 ea. Pump, Condensate
 1 ea. Pump, Distillate
 2 ea. Pump, Steering Gear, Hydraulic
 2 ea. Evaporator, Plant, Triple Effect
 1 ea. Evaporator, Plant
 5 ea. Compressor, Air Electric
 2 ea. Generator, Emergency, 850 KW AC, Fairbanks Morse

Hanger Deck:

8 ea. Winches, Electric
 1 ea. Antenna, Pedestal

Numerous Life Vest Racks.

Ammunition Magazine:

4 ea. Compasses, Repeaters

Various Electric motors, search lights, work lights, running lights, florescent area lights, electrical cable and electrical boxes.

Print Shop:

1 ea. Paper Drill
 1 ea. Paper Cutter
 3 ea. Printers

Sheet Metal Shop:

1 ea. Drill Press
 1 ea. Hack Saw

Machine Shop:

1 ea. Drill Press
 1 ea. Mill
 1 ea. Grinding Wheel
 2 ea. Lathers

This ship must be scrapped to the extent specified in Article SJ.

DEMIL CODE: D

CONTACT: PETE GALASSI PHONE (360)476-3510

LOCATION: MARE ISLAND NAVAL SHIPYARD, VALLEJO, CA

1 EACH

THERE ARE TANKS OF BALLAST WATER ON BOARD THAT CONTAIN REGULATED AMOUNTS OF SODIUM CHROMATE. PURCHASER IS CAUTIONED THAT IT IS SOLELY RESPONSIBLE TO ASCERTAIN THE EXTENT TO WHICH FEDERAL ENVIRONMENTAL LAWS AND OTHER STATE AND LOCAL STATUES AND REGULATIONS MAY AFFECT IT AND COMPLY THEREWITH.

STRIPPING: CUT AND REMOVE THE SHIPS NAME FROM THE STERN OF THE SHIP. CUT AT LEAST SIX (6) INCHES AROUND THE RAISED LETTERING. CONTACT THE FOLLOWING FOR PICKUP:

NATIONAL MUSEUM OF NAVAL AVIATION
ROBERT MACON, DIRECTOR
1750 RADFORD BLVD, SUITE C
PENSACOLA, FL 32508-4502
TEL: 850-452-3604, X119

DECLASSIFICATION: Declassification was previously completed. However, unclassified documents labeled "For Official Use Only", primarily located in the Supply Department Office, Compartment B-201-2-L, must be removed and destroyed as a condition of sale.

DEMILITARIZATION: See enclosure 10, Demilitarization Certification, to the pre-disposal documentation provided at the time of inspection. The following items require demilitarization as specified in enclosure 10:

- Catapult Cylinders
- Catapult Covers
- Sonar Transducers
- Aircraft Carrier Catapults
- Arresting Gear

Keypoint demilitarization was previously completed so as to preclude restoration or repair to a usable condition. All gun mounts and any other weapon systems must be further and totally destroyed by melting, cutting, tearing, scratching, crushing or breaking the item and components. Additionally, catapults and arresting gear equipment must be removed and demilitarized in accordance with NAVSEA Ltr 4710 ser 335D/2391 of 18 Jul 95, a copy of which is included in the pre-disposal documentation provided during the mandatory ship inspection prior to submission of proposals.

CONDITION OF SALE REMOVALS: As a condition of sale, the purchaser is required to remove (without further demilitarization) the SPS-30 Radar Antenna and the SPS-37/43 Radar Antenna Pedestal and large round reflector, stowed in the hanger bay, and make it available for pickup by the Aircraft Carrier Hornet Foundation (ACHF). ACHF point of contact is Pete Clayton, (619)461-9579.

END USE CERTIFICATE AND STATEMENT OF INTENT APPLIES AND MUST BE COMPLETED AND SUBMITTED WITH BIDS FOR THIS ITEM.

A. ENVIRONMENTAL AND SAFETY INFORMATION INSTRUCTIONS AND TERMS AND CONDITIONS:

Bidders are advised that they, not the Government, are responsible for obtaining all hazardous property information necessary to satisfy all standards required of a ship owner regarding the location, quantity, and content of asbestos on the ship(s) under 29 CFR 1915.1001(k), as well as for the information necessary to satisfy any other standards required of a ship/facility owner regarding the location, quantity, and content of any other hazardous property absent on the ship(s) offered under this IFB, under any other Federal or state statute or regulation. As the contracting activity, DRMS will provide all information available to it regarding hazardous property on the ship(s) offered under this IFB. However, it is the bidder's responsibility to ensure that the standards cited above, as well as any other Federal, state, or local laws or regulations pertaining to these ship(s), are complied with.

FUEL OIL RESIDUALS: The Purchaser is cautioned that fuel oil residuals that are present on these ship(s) may be a RCRA regulated waste. Pre-disposal documentation includes liquid load documentation which provides tank soundings and the volume of fuel oil remaining after stripping to low suction.

SODIUM CHROMATE: All tanks containing water which was added prior to 1990 for stability purposes while the ship was active or undergoing inactivation have been tested for sodium chromate concentrations. The pre-disposal documentation included these results and identified any water tanks that remain on board with regulated concentrations of chromate.

COATINGS: Ships of this type contain paint coatings that are lead or zinc oxide or chromate based. Due to the age of the ships, all coating must be assumed to be lead and/or zinc chromate based. The purchaser must implement controls required by OSHA and other regulations concerning worker safety and environmental compliance.

ASBESTOS:

(A) Ships of this type contain asbestos in the following applications:

- bulkhead and pipe insulation
- bulkhead fire shield
- uptake space insulation
- exhaust duct insulation
- some electrical cable materials
- brake linings
- floor tiles and deck underlay
- steam, water and vent flange gaskets
- flexitalic gaskets
- garlock seals
- shaft packing
- valve packing
- pipe hanger inserts
- weld shop protectors and burn covers
- any other type of thermal insulating material

(B) The access door(s) to compartments containing asbestos insulation have been labeled to indicate that asbestos is present and whether the asbestos insulation is in a friable or non-friable condition. The pre-disposal documentation includes a Asbestos Survey Report which is a compartment listing which is provided at the time of inspection. The compartment listing does not represent or characterize the total quantity of asbestos containing materials (ACM) throughout the ship. Bidders are cautioned that ACM may also be located underneath non-asbestos containing material. The compartment listing provides notification that ACM is present and whether it is in a friable or non-friable condition. Asbestos is a major health hazard as it enters the air as fibers or dust through operations such as ripout and removal. Compliance with OSHA (29 CFR, Part 1910), EPA (40 CFR, Part 61.02) and other agencies' regulations is required to ensure worker safety and proper disposal of asbestos containing materials. Access to the area shall be restricted to persons whose work requires their presence. Posted asbestos warning signs are not intended to substitute for asbestos danger signs required during asbestos remediation work. **THE GOVERNMENT EXPRESSLY DOES NOT WARRANT OR REPRESENT THAT COMPARTMENTS NOT POSTED WITH ASBESTOS WARNING LABELS DO NOT CONTAIN ASBESTOS.**

(C) The Purchaser shall be responsible for removing and disposing of all Asbestos in accordance with applicable Federal, State, and local laws and regulations. Further, each bidder shall rely on his own inspection in determining the method and extent of asbestos removal required under applicable laws and regulations. **THE GOVERNMENT EXPLICITLY DOES NOT WARRANT THAT THE ITEMS IDENTIFIED IN THE ASBESTOS SURVEY REPORT ARE THE ONLY ITEMS WHICH CONTAIN ASBESTOS IN REGULATED QUANTITIES.**

PCB ITEMS:

(A) A polychlorinated biphenyl (PCB) inventory of all electrical and electronic equipment that contain or are suspected to contain PCB transformers and large capacitors has been accomplished and is provided with the pre-disposal documentation at the time of inspection. PCB labels are attached to the equipment for easy identification and each equipment is assigned a serialized number on the inventory for tracking purposes. This inventory represents the Navy's knowledge of the quantity of PCB transformers and large capacitors on board. **THE GOVERNMENT EXPLICITLY DOES NOT WARRANT THAT THE ITEMS IDENTIFIED IN THE PCB INVENTORY OR ITEMS POSTED ARE THE ONLY ITEMS WHICH CONTAIN PCBs IN REGULATED QUANTITIES.**

(B) A PCB sampling and laboratory analysis survey has been accomplished of potentially PCB solid materials on the ship and is provided with the pre-disposal documentation at the time of inspection. PCBs in concentrations regulated by Federal, State, and local laws and regulations exist on board the ship. The PCB Survey was distributed to parties who inspected the ships. The following applications may be found to contain regulated concentrations of solid PCBs:

- Ventilation duct flange gaskets, felt and rubber;
- Electrical cable insulation and other non-metallic components of cable;
- Fluorescent light ballast starters and potting;
- Bulkhead and pipe insulation;
- Foam rubber/plastic anti-sweat insulation used on hull surfaces and cold water piping;
- Cork hull anti-sweat insulation;
- Other rubber items such as pipe hanger rubber blocks, snubbers, bumpers, shock and

vibration mounts, pads, spools, hatch gaskets, O-rings, packing and grommets, etc.;
Adhesive tapes and double-backed adhesive tapes;
Aluminized paints;
Any gloss oil-based paints; any oils and greases.

All regulated PCB items must be removed and disposed of in accordance with applicable Federal, State, and local regulations.

THE GOVERNMENT EXPLICITLY DOES NOT WARRANT THAT THE PCB ITEMS IDENTIFIED IN THE SURVEY REPORT ARE THE ONLY REGULATED PCB ITEMS ON BOARD, NOR THAT THE SURVEY REPORT IS REPRESENTATIVE OF THE QUANTITY OF PCB CONCENTRATIONS IN ALL LOCATIONS OR MATERIALS ON BOARD.

(C) The Purchaser shall be responsible for identifying, handling, and disposing of all items containing PCB contamination in quantities regulated under applicable Federal, State, and local laws and regulations in accordance with applicable Federal, State, and local laws and regulations. (See Sale by Reference, including Part 7, Article R, and Invitation for Bids Conditions of Sale, Articles SB, SE, SG, SJ, and SL).

OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA) REGULATIONS:
At a minimum, dismantling and scrapping must be in accordance with OSHA regulations at 29 CFR Parts 1910 and 1915, Shipbreaking.

ENVIRONMENTAL PROTECTION: All bidders are advised that they must comply with all applicable Federal, State, and local laws, ordinances, regulations, etc., with respect to human safety and the environment during the processing, use or disposal of material purchased from the Department of Defense under this contract.

REGULATED SUBSTANCES: PCB, asbestos or other hazardous or toxic items or components not identified in the item description may remain on the ship being offered in this Invitation for Bids. Strict adherence to Federal environmental statutes, U.S. Environmental Protection Agency (EPA) regulations, State and local environmental laws and regulations are required for this item. Purchaser is cautioned that it is solely responsible to ascertain the extent to which Federal environmental laws and other State and local statutes and regulations may effect it and comply therewith.

RESOURCE CONSERVATION AND RECOVERY ACT NOTICE: EPA Hazardous Waste Regulations, 40 CFR Part 260 et seq., published at 45 Federal Register 33063-33285, May 19, 1980, became effective on November 19, 1980. These cradle-to-grave regulations detail the responsibilities of generators, transporters, treaters, storers, and disposers of hazardous waste. Civil and criminal penalties are available for noncompliance. While the material offered under this solicitation is not subject to these regulations in its present form, subsequent actions taken with regard to the material may cause a hazardous waste to come into existence. Bidders are cautioned that he is solely responsible to ascertain the extent to which these regulations effect it and comply therewith.

B. TERMS & CONDITIONS OF SALE

IN ADDITION TO THE ABOVE, THE FOLLOWING IS ALSO INCORPORATED AS PART OF THIS SALE

The following General Information and Instructions and Special Conditions of Sale contained in Defense Reutilization and Marketing Service pamphlet entitled "Sale by Reference - Instructions, Terms and Conditions Applicable to Department of Defense Personal Property Offered for Sale by Defense Reutilization and Marketing Service, March 1994", are hereby incorporated by reference and become a part of this IFB and any resulting contract:

Part 1: General Information and Instructions (DRMS Form 81, Oct 93).

Part 2: General Sale Terms and Conditions (Standard Form 114C, Jun 86 ed.; and DRMS Form 84, Oct 93), All Conditions, except Condition No.s 4, 7, 9, 28, and 30.

Part 3: Special Sealed Bid Conditions (Standard Form 114C-1, Jan 70 ed.; and DRMS Form 99, Oct 93), All Conditions except Condition A, and D. **Condition E applies to predetermined lots only. Condition E does not apply to individual line items in this IFB.**

Part 5: Additional Special Circumstance Conditions (DRMS Form 86, Oct 93) as follows:

- Article B: Convict Labor
- Article C: Contract Work Hours and Safety Standards Act-Overtime Compensation
- Article D: Liability and Insurance
- Article E: Paper Records and Documents
- Article F: Privacy Act Materials
- Article I: Military Munitions List Items (MLI)
- Article K: Munitions List and Strategic List Items (MLI/SLI) Compliance

Part 6: Additional Special Circumstance Conditions- demilitarization and Mutilation (DRMS Form 95, Oct 93) as follows:

- Article B: Demilitarization or Mutilation on Other Than Government Premises
- Article D: Change in Contract Requirements
- Article E: Qualification of Bidders
- Article F: Subcontracts
- Article G: Government May Enter Premises
- Article H: Mutilation of Chlorobromomethane Fire Extinguishers

Part 7: Additional Special Circumstance Conditions-Hazardous and Dangerous Property (DRMS Form 98, Oct 93) as follows:

- Article C: Transporting Hazardous Material

Article E: Dangerous Property
Article F: Compressed Gas Cylinders
*Article J: Respiratory Protection Program
*Article L: Asbestos
*Article M: Packaging, Marking and Disposal of Asbestos
*Article N: Asbestos Dust Control, Housekeeping and
Clean-Up
Procedure
*Article O: Protective Clothing
Article R: Disposition and Use of Hazardous Property
Article S: Government's Right of Surveillance
Article U: Record Maintenance
Article W: Radioactive Material

*** SEE REVISIONS TO THESE ARTICLES IN THIS IFB**

**C. THE FOLLOWING DRMS SHIP SALE ARTICLES (Not Part of Sale By Reference)
ALSO APPLY AND CONSTITUTE TERMS AND CONDITIONS OF SALE:**

Reporting Articles

Article SN: Records, Progress Schedule, and Progress Report
Article SS: Incident Reporting

Environmental Articles

Article SB: Manifesting
Article SE: Generator Duties
Article SG: State Regulated Hazardous Waste
Article SK: Hazardous Property
Article SL: Permits
Article SQ: Scope of Work (Asbestos)
Article ST: Use of TSDFs and Transporters
Article TA: Segregation of Hazardous Waste

Payments, Defaults and Penalty Articles

Article SI: Storage Charges/Late Removal Charges
Article SO: Default in Performance of Scrapping,
Demilitarization and/or Stripping
Article SP: Default (Failure to Pay or Remove Ship(s) Within
Time Required by the Contract
Article SH: Bid Deposit and Payment

Operational Articles

Article SJ: Scrap Warranty
Article SC: Contract Performance
Article TC: Removal

Other Articles

Article SA: Title
Article SF: Risk of Loss
Article SM: Government Right of Inspection and Surveillance
Article SR: Prohibition on Use of Ship
Article SU: Termination for the Convenience of the Government
Article SV: Stop Work Order
Article SW: Contract Award
Article SX: Performance Bond
Article SY: Classified Material
Article SZ: Special Standards of Responsibility
Article TB: Severability
Article TC: Equal Opportunity

Reporting Articles

ARTICLE SN: RECORDS, PROGRESS SCHEDULE, AND PROGRESS REPORT.

(A) The Purchaser agrees to maintain all books, records detailing contract expenses and revenue, and other documents used to perform the contract and make such documents available to the Government for review and audit purposes. The Purchaser must further maintain such records for a period of two years after contract completion or for such a time as the Purchaser, for its own purposes, retains such books, records, and other documents, whichever is longer. The Purchaser agrees to furnish to the Sales Contracting Officer (SCO) a monthly report showing performance which has been accomplished to date of the report. The report shall be submitted by the 5th calendar day of the month and shall include the following information:

- (1) Progress achieved since the previous progress report including status of hazardous material abatement and disposal, approximate tonnage of scrap metals and equipment removed and shipped, and identification of the deck to which the ship has been dismantled. Also, identify the approximate percentage of completion of abatement and dismantling work on each ship.
- (2) Quantity and type of hazardous material shipped for disposal during the reporting period (to include copies of all manifests and other shipping or hazardous property disposal documents).
- (3) Progress in correcting any deficiencies identified by the DRMS inspection or by regulatory inspection.
- (4) Notification of any regulatory agency inspection conducted, of any Notices of Violations, citations, or cautionary notices received from regulators during the reporting period, relating to the performance of this contract. Also, notification of any other documentation relating to Federal, state, or local administrative or legal actions arising under or relating to the contract.
- (5) Progress expected to be achieved over the next month.
- (6) Assessment of risks relating to timely completion of this contract.
- (7) Status of outstanding permits/licenses required for performance of this contract, and status of any existing permits/licenses due to expire within 90 days of the Progress Report.
- (8) Advance notice of commencement of project activities that will require notification to any regulatory agency by Purchaser or any of its subcontractors.

The first progress report shall be submitted to the SCO within 30 calendar days after removal of ship(s). The Purchaser will include in the monthly progress report the Purchaser's plan to comply with the discrepancies noted or questions asked in writing by the SCO.

(B) Upon completion of each ship, the Purchaser shall provide a final report to include the requirements listed above as well as the following additional requirements:

- (1) Total dismantling labor hours;
- (2) Total abatement labor hours;
- (3) Disposal costs by wastestream;
- (4) Quantity of wastes disposed of by wastestream;
- (5) Quantity of scrap recovered for resale to include, but not limited to, ferrous, non-ferrous, and equipment.

The final report shall be submitted to the SCO within thirty (30) calendar days of completion of each ship.

(c) If the Purchaser's progress report or reports from the SCO's Representative indicate the Purchaser is falling behind schedule, the SCO may require the Purchaser to take such immediate steps as may be necessary to improve Purchaser's progress and to submit for the SCO's approval such supplemental schedule as may be deemed necessary to demonstrate the manner in which the agreed rate of progress will be regained without additional cost to the Government. Failure of the Purchaser to comply with the

requirements of this Article will be grounds for determination by the SCO that the Purchaser is not prosecuting the work with such diligence as will insure the completion of the Purchaser's obligations to the Government under the terms and conditions specified in the contract. Upon such determination, the SCO may, upon at least 15 calendar days written notice, calculated from the date of mailing, take action in accordance with Article SO, of the contract terms and conditions.

ARTICLE SS: INCIDENT REPORTING.

The Purchaser must provide written notification to the SCO within 24 hours of any incident involving injuries to personnel, spills, fires, explosions, damage to property or harm to the environment or any other significant incidents which may arise from other performance aspects under this contract.

The purchaser shall, within one week of receipt, provide copies of any notices of violation, citation, or other documentation relating to Federal, State, or local administrative or legal action against the Purchaser regarding actions arising under or relating to the contract.

Safety and Occupational Health Articles

THE FOLLOWING SALE BY REFERENCE PART 7 ARTICLES HAVE BEEN REVISED.
THESE ARTICLES REPLACE THE ARTICLES IN THE SBR.

PART 7, ARTICLE J:

Respiratory Protection Program.

Personnel shall be protected by personal protective equipment that provides full protection of nose, mouth, and respiratory system, in accordance with 29 CFR 1910.1001, 29 CFR 1915.1001 OSHA Standards for Shipyard Employment and 29 CFR 1926 OSHA Standards for Construction. Personnel engaged in the removal or demolition of pipes, structures, ships, or equipment covered or insulated with asbestos (as well as all other applicable safety and health hazards) and in the removal or demolition of asbestos insulation or coverings shall be provided and shall use respirators as stipulated in 29 CFR 1915.1001. Asbestos shall be presumed present unless shown to the contrary by bulk testing and air samplings.

PART 7, ARTICLE L:

Asbestos.

Purchasers are warned that unprotected exposure to asbestos fibers will significantly increase the risk of incurring four disease: Lung cancer, certain gastrointestinal cancers, mesothelioma and asbestosis. Care must be taken to avoid releasing or causing to be released, asbestos fibers into the atmosphere so that they may be inhaled or ingested. The Occupational Safety and Health Administration at 29 CFR 1910.1001, 29 CFR 1915.1001 Standards for Shipyard Employment and 29 CFR 1926 OSHA Standards for Construction, and 53 FR 35610 September 14, 1988, sets standards for permissible exposure to airborne concentrations of asbestos fibers, methods of compliance, personal protective equipment and other measures that must be taken when working with, or in proximity to, asbestos, in the U.S., its territories and possessions. Purchaser certifies that it will, as a minimum, comply with the provisions of 29 CFR 1910.1001, 1915.1001, 1926, and 53 FR 35610, September 14, 1988, in particular, 29 CFR 1915.1001(c) Permissible exposure limits (PELS); 29 CFR 1915.1001(f) Exposure assessments and monitoring; 29 CFR 1915.1001(h) Respirator fit testing; 29 CFR 1915.1001(j) Hygiene facilities and practices for employees; 29 CFR 1915.1001(k) communication of hazards; and 29 CFR 1915.1001(l) Demolition or salvage of structures, ships, and ship sections where asbestos is present in their entirety.

PART 7, ARTICLE M:

Packaging, Marking, and Disposal of Asbestos.

Asbestos waste, scrap, debris, bags, containers, equipment and asbestos-contaminated clothing consigned for disposal, which may produce airborne concentrations of asbestos fibers, shall be collected and disposed of in leak-proof, sealed, impermeable bags, as prescribed in 29 CFR 1915.1001 OSHA Standards for Shipyard Employment, 29 CFR 1926 OSHA Standards for Construction, 29 CFR 1910.1001, 53 FR 35610, September 14, 1988, and 40 CFR 61.20 et.seq. Prior to placing in bags, asbestos wastes shall be wet down to reduce airborne concentrations. It is essential that the waste asbestos material, whether in bags or containers, be disposed of by burial as specified in 40 CFR, Part 260 et.seq. and 40 CFR 61.140.

PART 7, ARTICLE N:

Asbestos Dust Control, and Housekeeping and Cleanup Procedures.

All external surfaces where work shall be performed must be maintained free of accumulations of asbestos fibers to prevent further dispersion. Meticulous attention must be given to restricting the spread of asbestos dust and all larger forms of waste. To the extent required by 29 CFR 1915.1001 OSHA Standards for Shipyard Employment, 29 CFR 1926 OSHA Standards for Construction, 29 CFR 1910.1001, and 53 FR 35610, September 14, 1988, an impermeable dropcloth under work areas, curtains and other enclosures designed to contain the asbestos dust and debris shall be used to keep asbestos from being distributed over the general area. To the extent required by 29 CFR 1915.1001, 1926 and 1910.1001 and 53 FR 35610, September 14, 1988, appropriate asbestos hazard warning signs shall remain posted until the site cleanup is complete and the soil, surrounding environment, water and atmosphere are tested and found safe. The cleanup crew should be under the direction and supervision of the Purchaser to ensure that proper cleanup is performed when asbestos dust/waste is present. All personnel engaged in cleaning up asbestos scrap and waste shall be equipped with the appropriate respiratory and protective clothing, as stipulated in 29 CFR 1915.1001, 1910.1001, 1926 and 53 FR 35610, September 14, 1988.

PART 7, ARTICLE O:

Protective Clothing.

Purchasers will provide and require their employees to wear coveralls and other clothing that will cover the entire body, head, hands, and feet when they are exposed to airborne concentrations of asbestos fibers (as well as all other applicable safety and health hazards) as specified in the 29 CFR 1915.1001 OSHA Standard for Shipyard Employment, 29 CFR 1926 OSHA Standards for Construction, and 1910.1001 and 53 FR 35610, September 14, 1988.

Environmental Articles

ARTICLE SB: MANIFESTING.

In the event that any item or component remaining on board the ship, whether or not identified in the Invitation for Bids, is subject to EPA/state regulations, the Purchaser is cautioned that it is solely responsible to ascertain the extent to which these regulations affect it and comply therewith. However, as a minimum, said item(s) or component(s) must be manifested with a transporter having an EPA Identification Number. Purchaser must complete all required manifest documents prior to each hazardous waste removal. Copies of the complete manifest must be provided to the SCO.

ARTICLE SE: GENERATOR DUTIES.

As a condition of sale of the ship(s) described herein, the Purchaser expressly a) acknowledges its duty to comply with the Toxic Substance Control Act, 15 U.S.C. S 2061 et seq., and the implementing regulations at 40 CFR Part 761; and b) agrees that it will perform all required duties, including those of the generator of PCB waste for any PCB item removed from the ship(s). In accordance with 40 CFR Part 761, the Purchaser expressly agrees that it will obtain an EPA Identification Number, arrange for all regulated wastes to be transported to an approved storage/disposal facility, prepare, sign and return all requisite copies of all manifests for the PCB items removed from the ship(s), and perform all communication and record-keeping tasks required by 40 CFR Part 761 as the generator of PCB waste. Purchaser expressly acknowledges its duty to comply with the Resource Conservation and Recovery Act, 42 U.S.C. 690 et seq., and the implementing Federal and State regulations, including expressly acknowledging that it will perform all duties required of the generator of hazardous waste.

ARTICLE SG: STATE REGULATED HAZARDOUS WASTE.

Items or components remaining on board the ship offered for sale, whether or not identified in the Invitation for Bids, may be regulated in the State where the ship will be berthed during contract performance. Purchaser is solely responsible for ascertaining the extent to which said State regulations effect it and for compliance therewith.

ARTICLE SK: HAZARDOUS PROPERTY DISCLAIMER/INDEMNIFICATION.

As previously noted, the Government cautions that the items sold under this contract, or material or substances, or component, part, constituent or ingredient therein may contain corrosive, reactive, or ignitable constituents, or exhibit other hazardous or toxic properties. The Government assumes no liability for any damage to the property of the Purchaser, any person or public property, or for the personal injuries, illness, disabilities or death to the Purchaser, Purchaser's employees or any other person subject to the Purchaser's control or any other person including members of the general public, arising from or incident to the purchase, use, dismantlement, scrapping, processing, disposition, or any subsequent operation performed upon, exposure to, or contact with any component, part, constituent or ingredient of this item, or substance or material whether intentional or accidental. The Purchaser agrees to hold harmless and indemnify the Government for any and all costs and expenses incurred incident to any claim, suit, demand, judgment, action, debt, liability costs, and attorney's fees or any other request for moneys or any other type of relief arising from or incident to the purchase, use, dismantlement, scrapping, processing, disposition, subsequent operation performed upon, exposure to or contact with any component, part, constituent or ingredient of this item, material, or substance, whether intentional or accidental.

ARTICLE SL: PERMITS.

The Purchaser shall be responsible for obtaining any necessary licenses and permits, and for complying with all Federal, State, and local laws and regulations in connection with the performance under the contract. This includes, but is not limited to, the required permits, licenses and notifications required to transport and dispose of hazardous and toxic waste regulated by RCRA and TSCA. This responsibility requirement will be a matter of inquiry during the SCO's pre-award evaluation of the Purchaser's capability to satisfactorily perform the contract. It will also be a continuing matter of inquiry by the SCO during the Purchaser's performance of the sales contract. The Purchaser is required to provide the SCO a copy of all necessary licenses, permits and notifications required for performance of this contract as cited in this article or elsewhere, prior to removal of any ship from Government control. The Purchaser must provide a copy of a signed lease for the scrapping site prior to removal, if the Purchaser does not own the facility where ship scrapping will occur.

ARTICLE SQ: SCOPE OF WORK (ASBESTOS).

The contract which results from the proposed sale includes the purchaser's provision of all labor, fees, transportation, equipment and facilities necessary to comply with the terms and conditions of the contract, including, but not limited to, the separation, stripping and removal of all asbestos so as to render it nonfriable if human exposure exceeds the limits specified in 29 CFR 1910.1001

ARTICLE ST: USE OF TSDFs AND TRANSPORTERS.

(A) The purchaser shall use only the transporters and treatment, storage, recycling and disposal facilities (TSDFs) from the Qualified Facilities List and Qualified Transporters List. These lists are located on the World Wide Web at either <http://www.drms.dla.mil> or <http://www.drms.dla.mil/environmental/environ.html>. Purchasers who do not have access to the World Wide Web may request a copy of the above lists from the SCO. See subparagraph (C)(1) and (2) of this Article for information on how the Purchaser may request that a TSDF or transporter be added to the qualified lists.

(B) DRMS has reviewed these TSDFs and Transporters in the past and has no reason to believe that they do not meet the standards of this Article. Inclusion of TSDFs and Transporters on the Qualified List does not constitute a determination of the acceptability of these TSDFs and Transporters for the requirements of this solicitation and any resultant contract or relieve the Purchaser of any responsibility for performing the contract resulting from this solicitation. It is the purchaser's responsibility to ensure that it can perform all work required by the IFB with the firms listed under Article ST and to propose additional firms under Article ST, subparagraphs (c)(1)-(2) to perform the work required if the TSDFs or Transporters listed in Article ST cannot meet the requirements. It does not imply consent by the Government to any subcontracts let by the purchaser in the performance of the contract resulting from this solicitation.

(C) If, during the life of the contract, the Purchaser requests approval of additional TSDFs or transporters, the Government must be allowed a reasonable amount of time to evaluate such requests. The Purchaser is not relieved of his contractual obligation to remove and dispose of all hazardous substances, hazardous materials and hazardous waste within contractual timeframes during the period the Government is evaluating the request(s) for additional TSDF(s) or transporters.

(1) The Purchaser shall provide the following information for RCRA permitted TSDFs including, but not limited to: complete address, telephone number, a copy of the permit excerpt to include the cover page(s), waste streams and treatment methods, closure funding, EPA identification number, and regulatory point of contact. The TSDF EPA identification number will be utilized to identify the facility on the DRMS Qualified TSDF list.

(2) The Purchaser shall provide the following information for each non-RCRA facility including, but not limited to: complete address, telephone number, a copy of the permit excerpt to include the cover page(s), waste streams and treatment methods, closure funding (if a regulated or permit requirement) and a federal/state/local compliance point of contact. If there is no regulatory or permit requirement for closure funding, comparable financial assurance coverage must be provided. A DRMS-created number will be assigned for approved non-RCRA facility for administration purposes.

(D) At any time during the period of this contract, the Government may disapprove a proposed TSDF or a previously approved TSDF if any of the following apply:

(1) The TSDF is currently closed.

(2) The TSDF is identified as a significant non-complier (exhibiting RCRA Class I violations for groundwater monitoring, closure, post-closure, or financial responsibility), and has not entered into a compliance schedule or similar action.

(3) The TSDF has been cited via an administrative order or judicial action, and the TSDF has not entered into a compliance schedule or similar action within 180 days from the time order or judicial action was issued.

(4) The TSDF has exhibited a history of noncompliance (including, but not limited to RCRA class I and II violations, OSHA violations, State and local violations and DoT violations) or exhibited a lack of good faith in correcting the violations. A "good faith" effort would be exhibited through promptly signing a consent agreement or similar document with appropriate regulatory authorities, and performing in compliance with the consent agreement or similar document for at least six months. Repeated violations may be considered as a lack of "good faith".

(5) The TSDF has been identified as having groundwater contamination or is not acceptable under the State's groundwater anti-degradation policy.

- (6) The TSDF is not permitted to and/or is not capable of handling the property proposed.
- (7) The TSDF received a negative recommendation as a result of a DRMS inspection visit during the preceding 12 months without substantive evidence of corrected deficiencies.
- (8) The TSDF stores/treats the waste, then ships out the regulated hazardous waste to a TSDF not approved by DRMS.
- (9) The TSDF's closure fund is not sufficient to protect the Government's long term interests.
- (10) A facility is unable to track property from entry to exit.

(E) At any time during the period of this contract, the Government may disapprove a proposed transporter or a previously approved transporter if any of the following apply:

- (1) The transporter does not have the appropriate Federal/State/local permits to transport property under this contract (hazardous or nonhazardous).
- (2) The transporter has exhibited a history of noncompliance (including RCRA, DoT, OSHA, and State and local regulations governing hazardous materials hauling and motor carrier/marine safety).
- (3) The transporter has been cited via administrative order or judicial action and has not entered into a compliance schedule or similar action within 180 days from the time the order or judicial action was issued.
- (4) The transporter has not provided documentation of at least a "Satisfactory" rating from the Department of Transportation (DoT) Office of Motor Carriers (OMC) or California Highway Patrol.

(F) The Purchaser will not add a fuels blender/burner or ship any subsequent residual waste derived from fuels blending to any facility/burner without prior approval from the SCO.

(G) Since transporters or TSDFs may be deleted at any time without notification, Purchasers should confirm the firm is on the Qualified TSDF list with the SCO prior to any actual usage under this contract.

ARTICLE TA: SEGREGATION OF HAZARDOUS WASTE

All hazardous waste items collected as a result of activities on this contract must be segregated and kept physically separate from any other items until the initial TSDF is reached. The items must be so marked that they are readily identified to this contract throughout this period. In addition, the Purchaser must ensure that there is a clear audit trail until final treatment/disposal is accomplished.

Payments, Defaults and Penalty Articles

ARTICLE SI: STORAGE CHARGES/LATE REMOVAL CHARGES.

If the Purchaser fails to remove the ship(s) in accordance with Article TC: Removal, or within any extension of time which may have been granted by the SCO pursuant to Part 2, Condition No. 8, General Sales Terms and Conditions, SBR Pamphlet, March 1994 (Standard Form 114C), the Government shall have the following remedies:

(A) Access charges for wharfage, moorage, dockage, anchorage, berthing or other services at the following rates per day per ship including Saturdays, Sundays, and Federal holidays:

| ITEM(S) | RATE PER DAY PER SHIP |
|---------|-----------------------|
| 1-12 | \$300.00 per day |

In all instances where storage charges are assessed, payment thereof must be made by the Purchaser prior to removal of the property unless otherwise authorized by the Government. Charges for late removal will not exceed 10 percent of the contract price of the ship(s).

(B) Exercise its rights under Article SP of this Invitation for Bids entitled "Default - Failure to Pay or Remove Ship(s) within Time Required by the Contract."

ARTICLE SO: DEFAULT IN PERFORMANCE

In the event the Purchaser fails to complete the scrapping, demilitarization and/or stripping of the ship(s) in accordance with the Purchaser's approved technical plan and the terms and conditions of the contract, or fails to comply with Federal, State, and local laws and/or regulations, or fails to prosecute the work with such diligence as will ensure the completion of the contract, and fails to correct such deficiencies within the period of time allowed by notice required by Article SN, the Government may send the Purchaser a Cure Notice stating the specific failure to perform and providing for a period of at least ten (10) calendar days in which to cure the failure. If the Purchaser has not cured the failure noted in the cure notice by the end of the period provided, the Government may send the Purchaser a 15 calendar day written notice of default (calculated from the date of mailing). If the Purchaser fails to cure the default cited in the default notice within the period (or such further period as the SCO may allow), the Government may terminate the contract and shall have the following remedies:

(1) If considered to be in the best interest of the Government, the Government may physically repossess some or all of the ships previously removed under the contract for which title has not passed. The Purchaser shall lose all right, title, and interest which he might have otherwise have acquired in the ship(s) removed by the Purchaser and repossessed by the Government. At the Government's election, the Purchaser shall also lose all right, title, and interest which he might otherwise have acquired in the ship(s) awarded but not removed under the contract. The Government may resell the ship(s) previously removed and unremoved by the Purchaser, charging the Purchaser with all costs incurred by the Government in repossessing, towing, storing, and reselling the property, including any direct loss on account of the resale and any costs associated with the Purchaser's failure to comply with Federal, State, and local laws and regulations, including but not limited to, the cost of any fines imposed by Federal, State, and local authorities, as well as for property disposal and treatment. In addition, the Government shall be entitled to retain or collect 10 percent of the original contract price as liquidated damages above and beyond the costs cited above to defray the indirect costs involved in effecting repossession and reselling the ships.

(2) If, because of the extent of scrapping, demilitarization and/or stripping performed by the Purchaser, the SCO determines that effecting repossession of the ship(s) would be impracticable, then the Government shall have the right to enter the premises of the Purchaser or its subcontractor(s) and, either with its own personnel or by contract, complete the scrapping, demilitarization, and/or stripping of the awarded ships. The Government may scrap and dismantle the ship(s) previously removed by the Purchaser, charging the Purchaser with all costs incurred by the Government in repossessing, scrapping and dismantling, and any costs associated with issuing a solicitation/contract to scrap and dismantle the property, including any direct loss on account of the resale and any costs associated with the Purchaser's failure to comply with Federal, State, and local laws and regulations, including but not limited to, the cost of any fines imposed by Federal,

State, and local authorities, as well as for property disposal and treatment. In addition, under no circumstances will the Purchaser be entitled to a refund of the purchase price.

(3) In the event that the Purchaser fails to comply with or perform any of the terms and conditions of this contract, the SCO may, at his discretion, assess the purchaser liquidated damages in the amount of \$1,000 per workday that the Purchaser is out of compliance.

ARTICLE SP: DEFAULT (FAILURE TO PAY OR REMOVE SHIP(S) WITHIN TIME REQUIRED BY THE CONTRACT).

If, after contract award, the Purchaser fails to make payment within the time allowed by the contract, or by failure to remove the property as required by Article TC: Removal, then the Government may send the Purchaser a 15 calendar day written notice of default (calculated from date of mailing), and if the Purchaser fails to cure the default cited in the default notice within that period (or such further period as the SCO may allow), the Government may, terminate this contract in whole or in part and the Purchaser shall lose all right, title and interest which he might otherwise have acquired in and to such property awarded under this contract, and the Government may exercise such rights and may pursue such remedies as are provided by law or under the contract. The Purchaser further agrees that in the event it fails to pay for the property or remove same in accordance with the terms of the contract and within the prescribed period(s) of time, the Government at its election and upon notice of default shall be entitled to retain (or collect) as liquidated damages a sum equal to 10 percent of the purchase price of the item (or items) as to which the default has occurred. When the Government exercises this election, it shall specifically apprise the Purchaser, either in its original notice of default (or in a separate subsequent written notice), that upon the expiration of the period prescribed for curing the default, 10 percent of the purchase price will be retained (or collected) by the Government as liquidated damages.

ARTICLE SH: PAYMENT

(A) Full payment of the contract purchase price, for the ships to be removed, is due prior to the date of removal from Government control. Payment is considered late when the payment is not in the possession of the SCO, or the designated representative, as of close of business, 4:30 p.m. Eastern time on the date of removal of each ship from Government control in accordance with Article TC: Removal. When the full payment due date falls on a Federal holiday or other day when the facility is closed, the payment is due on the following business day.

(B) All payments, including those for storage charges, liquidated damages, and interest, must be in U.S. currency in the form of cash, cashier's check, certified check, traveler's check, bank draft, money order or credit card (Mastercard or Visa only). When a credit card is used as payment, the credit card number, the name as printed on the credit card, and the expiration date must be provided. If more than one credit card is used, the Purchaser must identify the exact monetary amount to be applied against each credit card. Purchasers whose payment is accompanied by a letter of credit, or who have on file an approved bid bond (SF 150 or SF 151), may make payments by uncertified personal company checks, but only up to an amount equal to the penal sum of their bond or the amount of their letter of credit.

(C) If, for any reason, a Purchaser's uncertified check is not honored for payment by the payee's bank upon initial presentment for payment, the Government may, after notifying the Purchaser, require the Purchaser to make all future payments by cash, cashier's check, certified check, traveler's check, bank draft, or money order.

(D) Successful bidders that wish to make payment via credit card for property awarded can do so by providing language substantially as follows:

I (WE) AUTHORIZE THE SCO TO OBTAIN PAYMENT BY CREDIT CARD FOR ANY ITEMS I AM (WE ARE) AWARDED ON THIS SALE.

Operational Articles

ARTICLE SJ: SCRAP WARRANTY.

The Purchaser agrees, represents, warrants and certifies that:

(1) This/these ship(s) will be completely scrapped by demilitarizing in compliance with the demilitarization requirements specified in the item description as applicable and by final dismantlement and mutilation of the hull and superstructure in such a manner that no considerable part of the ship is left intact or undisturbed to the extent that it can be reconstructed or readily identified as an existing portion of the original hull or superstructure.

This will include the removal from the ship(s) (without replacement) of all hull, inner bottom, bulkhead, deck and deck house material, as well as all floors, longitudinals, webs, girders and other framing. The term "hull" means the framework of a ship, including the keels, together with all decks, deck houses, tanks, the inside outside plating and all bulkhead, but exclusive of masts, yardarm, rigging, machinery, outfitting and equipment.

(2) The Purchaser further agrees that the Purchaser or his/her subcontractor will complete the required scrapping described above in the United States or its territories. The Purchaser further agrees that the ship will not be used or transferred by the Purchaser except for the purposes of scrapping as described above and approved in the technical plan.

(3) The Purchaser further agrees and certifies that all scrapping operations for lot 1 (items 1-6) will be completed by the Purchaser or his designee within three calendar years from the time of taking possession and removal from Government control of the first ship(s) removed in accordance with Article TC: Removal.

(4) The Purchaser further agrees and certifies that all scrapping operations for lot 2 (items 7-12) will be completed by the Purchaser or his designee within three calendar years from the time of taking possession and removal from Government control of the first ship(s) removed in accordance with Article TC: Removal.

(5) The Purchaser further agrees and certifies that all scrapping operations for item 13 will be completed by the Purchaser or his designee within three years from the time of taking possession and removal in accordance with Article TC: Removal.

(6) The Purchaser further agrees and certifies that in the event it bids on and is awarded more than one lot or item, the timeframe for completion of each lot or item will be as specified in subparagraphs (3), (4), and (5) of this article. The timeframe for completion of each lot and/or item awarded to an individual Purchaser, will run concurrently for each lot and/or item awarded. For example: If a Purchaser is awarded Lot 1 and Lot 2 and removes the first ships from Lot 1 on March 15, 1998, and removes the first ships from Lot 2 on April 15, 1998, the completion date for Lot 1 is March 15, 2001 and the completion date for Lot 2 is April 15, 2001.

(7) The Purchaser further agrees and certifies upon completion of the scrapping operation, the Purchaser will furnish to the SCO a certificate to the effect that all scrapping by this provision has been accomplished and all Federal, State, and local laws and regulations have been complied with. The SCO or his successor may extend the above completion dates of scrapping operations when determined, in writing, that the delay in completion is due to causes beyond the control and

without the fault or negligence of the Purchaser, or when determined it is otherwise in the best interest of the Government.

ARTICLE SC: CONTRACT PERFORMANCE.

Purchaser understands and agrees to submit a written request for contract modification to the SCO prior to effecting any change from that Stated on its Statement of Intent, Technical Proposal, End-Use Certificate, and/or Sale of Government Property-Item Bid Pages, Sealed Bid, whether occurring before or after the release of the ship(s). The Purchaser further agrees not to effect such changes without first receiving the written approval of the SCO. The Government reserves the right to visit the facility of the Purchaser or subcontractor responsible for the actual scrapping of the ship during the performance of the contract. The Government also reserves the right to meet with the Purchaser periodically to hold progress reviews for the purpose of assessing the scrapping status and to monitor compliance with safety and environmental laws and regulations. The Purchaser shall proceed diligently with performance of this contract, pending final resolution of any request for relief, claim, appeal, or action arising under or relating to the contract, and comply with any decision of the SCO regarding same.

ARTICLE TC: REMOVAL

(A) The Purchaser will make the initial removal of ships as follows:

- Lot 1: Two ships within 60 calendar days after contract award;
- Lot 2: Two ships within 60 calendar days after contract award; and
- Item 13: Within 60 calendar days after contract award.

Subsequent removals shall be in accordance with the purchasers approved technical plan.

(B) The purchaser shall request authorization from the SCO to remove additional ships from each lot. Prior to release of the next ship(s), the SCO shall evaluate the Purchaser's performance to determine compliance with the terms and conditions of the contract and Federal, State and Local regulations. This shall also include an evaluation of the cutting and scrapping schedule in the Purchaser's Approved Technical Plan. The last two ships in each lot shall not be released until the first two ships are 100 percent complete.

(C) The Purchaser is required to provide five days written notice to the Navy custodians prior to removal of the ships.

Other Articles

ARTICLE SA: TITLE.

Title to the scrap, parts and/or components available for removal shall vest in the Purchaser as and when said property is physically removed from the ship or residue thereof.

ARTICLE SF: RISK OF LOSS. The Purchaser assumes sole responsibility for the security and protection of the property purchased under the contract upon commencement of removal from the Government facility by the Purchaser, its agent or authorized representative. The Purchaser further assumes responsibility for the security of the property and of its equipment upon commencement of removal of the ships. This responsibility is in addition to the coverage provided under Part 2, Condition 14, Sales By Reference pamphlet, March 1994.

ARTICLE SM: GOVERNMENT RIGHT OF INSPECTION AND SURVEILLANCE.

In addition to the Government's right of surveillance and inspection set out in the Sale by Reference, Part 7, Article S; Part 6, Article G; the Purchaser is informed that the Government's or its authorized representative's right to observe all aspects of the work process may include inspection and surveillance up to 100 percent of the work process. The Government will also have the right to conduct a post-award conference with the awardee. The Purchaser is also informed that the Government's or its authorized representative's inspection and surveillance includes the right to verify the accuracy of the results of tests performed by the Purchaser as part of its obligation to comply with Federal, State, and local environmental laws and to verify that all environmental requirements are complied with.

ARTICLE SR: PROHIBITIONS ON USE OF SHIP.

The Purchaser's rights under this contract are limited to scrapping and sale of usable material. Since title to the ship is retained by the Government until all material is completely removed/scrapped in accordance with Article SJ of this IFB, any other activities on board the ship are prohibited without prior approval by the SCO. These prohibited activities include, but are not limited to, memorial services, luncheons and tours.

ARTICLE SU : TERMINATION FOR THE CONVENIENCE OF THE GOVERNMENT

The SCO, by written notice, may terminate performance of work under this contract in whole or in part if the SCO determines that a termination is in the Government's best interest. If this contract is terminated for the convenience of the Government, the Government shall be liable only for the purchase price paid under the contract, and reasonable costs incurred by the Purchaser for work performed under the contract prior to the effective date of termination, notwithstanding Part 2, Condition 15 of the Sale by Reference Pamphlet, March 1994.

After receipt of a notice of termination for convenience, unless otherwise directed by the contracting officer, the Purchaser shall immediately proceed with the following obligations, regardless of any delay in determining potential amounts due under this termination:

1. Stop work as specified in the notice.
2. Place no further subcontracts or orders for supplies or services other than those required to complete any continued portion of the contract.
3. Terminate all subcontracts to the extent they relate to the work terminated.
4. Complete performance of the work not terminated.
5. Assign to the Government, as directed by the SCO, all right, title and interest of the Purchaser under the subcontracts terminated.
6. With approval to the extent required by the SCO, settle all outstanding liabilities and termination settlement proposals arising from the termination of subcontracts.
7. As directed by the SCO, transfer title and deliver to the Government any property, plans, or other information required to be furnished to the Government as if the contract had been completed.
8. Take any action that may be necessary, or that the SCO may direct, for the protection and preservation of the property related to this contract that is in the possession of the Purchaser and in which the Government has an interest.

If appropriate, the Purchaser shall submit its final settlement termination proposal to the SCO in the form and with the certification prescribed by the Contracting Officer within 90 days of the effective date of termination.

ARTICLE SV : STOP WORK ORDER

The SCO may, at any time, by written order to the Purchaser, require the Purchaser to stop all, or any part, of the work called for by this contract for a period of up to 90 days after the order is delivered to the Purchaser, and for any further period to which the parties may agree. The order shall be specifically identified as a stop-work order issued under this clause. Upon receipt of the order, the Purchaser shall immediately comply with its terms and take all reasonable steps to minimize incurring costs allocable to the work covered by the order during the period of work stoppage. Within a period of 90 days after a stop-work order is delivered to the Purchaser, or within any extension of that period to which the parties shall have agreed, the SCO shall either--

(1) Cancel the stop-work order; or

(2) Terminate the work covered by the order as provided by the Default in Performance or Termination for Convenience clauses of this contract.

If a stop-work order issued under this clause is canceled or the period of the order or any extension thereof expires, the Purchaser shall resume work. The SCO shall make an adjustment in the delivery schedule and the contract shall be modified, in writing, accordingly, if--

(1) The stop-work order results in an increase in the time required for the performance of any part of this contract; and;

(2) The Purchaser asserts its right to the adjustment within 30 days after the end of the period of work stoppage.

ARTICLE SW: CONTRACT AWARD.

Award of each lot and/or item will be made to the responsive, responsible bidder who has submitted an acceptable technical proposal under step one of this two-step solicitation and that submits the highest price bid. The accepted technical proposal will be incorporated into, and made part of the resultant contract. No change in the technical plan, including subcontractors identified therein, shall be made after award unless the change is approved by the SCO. Prior to award of a contract, the SCO will determine whether the bidder is a responsible prospective Purchaser. The Government also reserves the right to meet with the contractor periodically to hold progress reviews for the purpose of assessing the scrapping status and to monitor compliance with safety and environmental laws and regulations. This may include the accomplishment of an on-site pre-award survey to evaluate a prospective Purchaser's capability to perform according to the terms and conditions of the proposed contract.

ARTICLE SX: PERFORMANCE BOND.

A. The Purchaser agrees to furnish to the SCO a Performance Bond on Standard Form 25 (Certified or cashier's checks, bank drafts, irrevocable letter of credit, post office money orders, or currency may be furnished with Standard Form 25 in lieu of a designated acceptable surety company) in the sum of \$50,000 for items 1-12 and \$200,000 for item 13 to cover the purchaser's obligation to complete the contract. Performance bonds must be submitted with contract payment. For lot sales, a Performance Bond shall be submitted for each ship in each lot awarded. All Performance Bonds submitted to the Government on this contract must be issued by a firm with at least an "A-" rating from A.M. Best or an equivalent rating service.

B. The SCO shall release the performance bond upon verification of the Purchaser's certification of completion and upon the SCO's determination that all hazardous materials abated from the ship have been properly disposed of and that any facility environmental issues have been satisfactorily resolved.

ARTICLE SY: CLASSIFIED MATERIAL

Any classified or secret material found by the Purchaser or its subcontractor(s) in the ships referred under this contract must be immediately returned to Government control, as directed by the SCO, at the Government's expense.

ARTICLE SZ: SPECIAL STANDARDS OF RESPONSIBILITY

The following special standards of responsibility will be assessed in addition to the general standards in determining responsibility of all prospective purchasers:

A satisfactory history of compliance with Federal, State, and Local environmental laws and regulations.

A satisfactory history of compliance with Federal, State, and Local safety laws and regulations.

These standards will also be applied to key personnel and subcontractors identified in the prospective purchaser's approved technical proposal. Corrective actions taken in response to previous violations will be taken into consideration in assessing a prospective purchaser's responsibility.

ARTICLE TB: SEVERABILITY

Any terms, conditions, or provisions of the contract resulting from this Invitation for Bids found to be invalid, void, or illegal shall in no way effect impair or invalidate any other terms or provision herein and such remaining terms and provisions shall remain in full force and effect.

ARTICLE TC: EQUAL OPPORTUNITY

The following clause is applicable unless the contract is exempt under the rules, regulations, and relevant orders of the Secretary of Labor (41 CFR, ch. 60) Exemptions include contracts and subcontractors (i) not exceeding \$10,000 and (ii) where no appreciable amount of work is to be done by the contractor:

During the performance of this contract, the contractor agrees as follows:

- (a) The contractor will not discriminate against any employee or applicant for employment because of race, color, religion, sex, or national origin. The contractor will take affirmative action to insure that applicants are employed, and that employees are treated during employment without regard to their race, color, religion, sex, or national origin. Such action shall include, but not be limited to the following: Employment, upgrading, demotion, or transfer; recruitment or recruitment advertising; layoff or termination; rate of pay or other forms of compensation; and selection for training, including apprenticeship. The contractor agrees to post in conspicuous places, available to employees and applicants for employment, notices to be provided by the Contracting Officer setting forth the provisions of this nondiscrimination clause.
- (b) The contractor will, in all solicitations or advertisements for employees placed by or on behalf of the contractor, state that all qualified applicants will receive consideration for employment without regard race, color, religion, sex, or national origin.

- (c) The contractor will send to each labor union or representative of workers with which he has a collective bargaining agreement or other contract or understanding, a notice, to be provided by the agency Contracting Officer, advising the labor union or workers' representative of the contractor's commitments under Section 202 of Executive Order No. 11246 of September 24, 1965, and shall post copies of the notice in conspicuous places available to employees and applicants for employment.
- (d) The contractor will comply with all provisions of Executive Order No. 11246 of September 24, 1965, and of the rules, regulations and relevant orders of the Secretary of Labor.
- (e) The contractor will furnish all information and reports required by Executive Order No. 11246 of September 24, 1965, and by the rules, regulations and orders of the Secretary of Labor, or pursuant thereto, and will permit access to his books, records, and accounts by the contracting agency and the Secretary of Labor for purposes of investigation to ascertain compliance with such rules, regulations, and orders.
- (f) In the event of the contractor's noncompliance with the nondiscrimination clauses of this contract or with any of such rules, regulations, or orders, this contract may be canceled, terminated or suspended, in whole or in part, and the contractor may be declared ineligible for further Government contracts in accordance with procedures authorized in Executive Order No. 11246 of September 24, 1965, and such other sanctions may be imposed and remedies invoked as provided in Executive Order No. 11246, of September 24, 1965, or by rule, regulation, or order of the Secretary of Labor or as otherwise provided by law.
- (g) The contractor will include the provisions of paragraphs (a) through (g) in every subcontract or purchase order unless exempted by rules, regulations or orders of the Secretary of Labor issued pursuant to Section 204 of Executive Order No. 11246 of September 24, 1965, so that such provisions will be binding upon each subcontractor or vendor. The contractor will take such action with respect to any subcontract or purchase order as the contracting agency may direct as a means of enforcing such provisions, including sanctions of noncompliance; provided, however, that in the event the contractor becomes involved in, or is threatened with, litigation with a subcontractor or vendor as a result of such direction by the contracting agency, the contractor may request the United States to enter into such litigation to protect the interests of the United States.

Remember . . .

RFTPs are due by the official opening time.
Please do **not** wait until the last minute!



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APPENDIX E
SHIP SCRAPPING AND PCBS - BACKGROUND PAPER
AND ADMINISTRATOR'S FACTSHEET

SHIP SCRAPPING AGREEMENTS AND PCBs - BACKGROUND PAPER

Background:

Under the current Toxic Substances Control Act (TSCA) regulations, export of PCBs at concentrations of 50 ppm or greater for purposes of disposal is prohibited. In 1994, EPA proposed to allow the export of PCBs for disposal (59 Fed Reg. 62788). It was EPA's intent, with this rulemaking, to generally treat the transboundary movement of PCBs the same as the transboundary movement of other hazardous waste which is controlled under the Resource Conservation and Recovery Act (RCRA).

Pending the finalization of the export provisions of this rulemaking, EPA entered into interim Agreements with the Navy and U.S. Maritime Administration (MARAD) to allow the export of ships containing PCBs for scrapping, provided certain materials were removed from the vessels prior to export. The Agreements require the removal of specified liquid PCBs and solid PCB items that are readily removable. The Agreements also contain provisions requiring notice to the importing country.

In response to concerns raised by the media about poor environmental and health and safety conditions in overseas scrapping facilities, both Navy and MARAD agreed to suspend exporting ships under these Agreements until after the Report of the Interagency Panel on Ship Scrapping was issued and they met with EPA to discuss the Agreements.

Question: Now that the Report of the Interagency Panel has been issued, does EPA plan to allow the export of ships for scrapping under the current Agreements?

Answer: Based on decisions made during the interagency review of both the domestic and international ship scrapping industries, EPA is more confident that scrapping can be done domestically in a way that is both environmentally safe and which protects the health and safety of the workers in this industry. For example, Navy, MARAD, EPA and OSHA have agreed to enter into a cooperative agreement under which the Defense Logistics Agency and MARAD will notify EPA and OSHA when a contract has been let and the location of the proposed scrapping operation. This will enable EPA to plan for and conduct timely inspections of ship scrapping operations. EPA and OSHA will be included in post/award/pre-performance conferences at which environmental and occupational health and safety plans are reviewed. EPA has agreed to work with Defense Logistics Agency, MARAD and OSHA to develop a compliance manual that will outline for ship scrappers the relevant environmental and occupational health and safety requirements of their contracts and applicable laws and statutes.

We do recognize, however, that the number of ships currently needing to be scrapped exceeds the capacity of the domestic industrial base. Because of this limitation, we supported the decision of the Panel to not foreclose the option of international scrapping. We also recognized that improvements could be made in the export Agreements. One change agreed to was to expand the notification requirement regarding specific ships to include more detailed information about the materials commonly found on these ships. The notification provision will also be revised to

provide for tacit agreement by the receiving country, if there is no objection within 30 days of notification. A similar provision was included in an Agreement with MARAD in 1995. Under that Agreement, the Government of India was notified of the potential export of two vessels containing PCBs in paint for scrapping. Before the vessels were to be exported, India responded that it had not been aware of the various PCB uses on vessels and declined the export, pending further study of the issue. In addition to proposed changes in notification, we have agreed that, if the Agreements are reactivated, they should be reviewed annually to evaluate their use and to determine whether they should remain in effect. The first step will be for us to meet with both the Navy and MARAD to discuss the Agreements, which was a commitment made during the Panel review process.

Question: Why don't the Agreements require the removal of hazardous materials other than PCBs from ships before they are exported for scrapping?

Answer: The Agreements address the export of PCBs because under the implementing regulations of TSCA, export of PCBs at concentrations of 50 ppm or greater for purposes of disposal is prohibited. With the exception of PCBs, neither TSCA nor RCRA prohibits the export of asbestos or other hazardous materials and wastes, provided applicable regulations for export, including prior notice or notice and consent are followed. EPA interprets its regulations as not prohibiting the export of intact ships containing asbestos or other hazardous materials when the vessels will continue to be used. The Agency has not yet determined whether partially dismantled ships containing hazardous material components are subject to the RCRA hazardous waste export controls when the vessels are exported for scrapping.

Question: What does EPA intend to do domestically to ensure that situations like the Coral Sea do not occur again?

Answer: Discussions on the Panel have been instructive in helping EPA to identify areas in which we can improve our own oversight and enforcement to ensure that domestic scrapping is done in compliance with the applicable environmental laws. For example, Navy, MARAD, EPA and OSHA have agreed to enter into a cooperative agreement under which the Defense Logistics Agency and MARAD will notify EPA and OSHA when a contract has been let and the location of the proposed scrapping operation. This will enable EPA to plan for and conduct timely inspections of ship scrapping operations. EPA Region 6, along with EPA's National Enforcement Investigations Center, will be visiting several ship scrapping operations in the Gulf Coast area to learn more about the logistics of scrapping. We also identified ways in which we can work more closely with Navy, MARAD and OSHA to develop compliance protocols for ship scrappers and to educate the ship scrapping industry about environmental and health and safety requirements applicable to the industry.

Background: The Coral Sea situation:

EPA found a pattern of improper asbestos removal and disposal and dumping of debris and discharging oil into surrounding waters at the USS Coral Sea and the US Illusive ship scrapping operation. The USS Coral Sea operation was under contract to Kerry Ellis and Seawitch

Salvage. In its investigations of the USS Coral Sea ship scrapping operation, EPA discovered asbestos containing material from samples taken from exposed pipes in scrapped areas of the ships; there was no evidence that this material had been removed or handled in accordance with the asbestos abatement requirements required under the Clean Air Act. Workers at the site also claimed, and later testified at the subsequent criminal trial of Ellis, that they were told by Ellis the pipe insulation contained no asbestos. Workers testified that Ellis directed them to remove this pipe insulation, and that they generally were instructed to do so without proper and adequate protective clothing. Workers were also illegally directed by Ellis to hose down the decks of the Coral Sea with a fire hose, causing tons of debris to be washed into the Patapsco River. They were also illegally directed by Ellis to use large quantities of Dawn dish washing detergent to dissipate and conceal the oil sheen it left on the river.

Ellis and Seawitch Salvage were convicted of three counts of violating the Clean Air Act for failing to file a notification of asbestos removal for the USS Illusive and the illegal removal of asbestos on the USS Illusive and the USS Coral Sea. They were also convicted of two counts of violating the Clean Water Act for dumping debris and discharging oil from the Coral Sea into the waters of the United States; one count of violating the Rivers and Harbors Act for dumping debris into waters of the United States; and one count of making a false statement to the United States Government for lying about the quantity of asbestos removed from the Coral Sea by a licensed asbestos contractor. Mr. Ellis was sentenced to 30 months imprisonment, fined \$50,000, and given three years probation. Seawitch Salvage was fined \$50,000 and given three years probation.

Question: What does the Navy and MARAD intend to do to ensure that situations like the Coral Sea do not occur again?

Answer: The Navy and the Defense Logistics Agency (DLA), which acts as the Navy's disposal agent, have significantly upgraded their procedures for awarding domestic ship scrapping contracts. The Navy and DLA report that they now conduct numerous, sometimes daily inspections of scrapping operations. MARAD is upgrading its contracting procedures, but claims it does not have the resources or the expertise to conduct the intensive oversight program that DOD is implementing.

Question: What are some of the specific panel recommendations in the report that EPA will be involved in implementing to improve domestic scrapping?

Answer: In the area of leveraging regulatory oversight, the report recommends that EPA enter into a Memoranda of Agreement (MOA) with the Occupational Safety and Health Administration (OSHA), DLA, Navy and MARAD to set out responsibilities for coordination and information sharing. The report suggests that EPA conduct comprehensive, multimedia, environmental inspections of ship scrapping operations, which may include a teaming effort with OSHA. The report also recommends that EPA coordinate with the other agencies in the development of a compliance manual and other educational outreach mechanisms for educating the ship scrapping industry in the regulations and expectations of the U.S. Government.

The report recommends the development of PCB guidance for testing, removal and disposal of non-liquid PCBs on vessels to be scrapped. The "removal" and "disposal" components are addressed in the PCB disposal amendments that are to be promulgated in May, 1998. EPA cannot begin developing the "testing" component without first analyzing data collected by DOD, MARAD, and Coast Guard on non-liquid PCBs.

Congressional Issues

- After reviewing the Report of the Ship Scrapping Panel, Senator Mikulski expressed her concern that the Report did not recommend aggressive enough steps to correct the ship scrapping situation faced by the U.S. government.
- Senator Mikulski has drafted legislation which would prohibit the sale of naval and MARAD vessels for scrapping abroad unless the Administrator of EPA certifies to the Secretary of the Navy or Transportation that the environmental standards of the importing country are similar to those of the United States and would establish a demonstration program for breaking up naval and MARAD vessels in U.S. shipyards.
- In a public meeting held by the Ship Scrapping panel on March 5, 1998 in Washington, D.C., Senator Mikulski focussed on the importance of turning the large number of ships that needed to be scrapped into opportunity for American shipyards. She also noted the importance of not exporting our environmental problems.

ADMINISTRATOR'S FACTSHEET

SCRAPPING OF NAVY AND MARITIME ADMINISTRATION SHIPS CONTAINING PCBs

PROGRAM/ISSUE: Because of the large number of U.S. government ships designated for scrapping (currently over 180), and the uncertain capacity of the domestic ship scrapping market, the Navy and U.S. Maritime Administration (MARAD), sought enforcement discretion agreements with EPA that would allow them to export vessels for scrapping which contain regulated quantities of PCBs. EPA entered into Agreements with both the Navy and MARAD for overseas disposal of surplus vessels containing non-liquid PCBs.

In response to issues raised in the media about poor environmental and health and safety conditions in overseas scrapping facilities, the Navy and MARAD agreed to temporarily suspend efforts to export surplus ships to foreign countries for scrapping pending an inter agency review of Navy and MARAD ship scrapping programs. A report, including recommendations focussed on both domestic and international ship scrapping, was released to Congress on April 20, 1998. The Report recommended that export of vessels should not be foreclosed and made specific recommendations for improvements in management and oversight of domestic scrapping and improvements in the export agreements. [Senator Mikulski has expressed concerns that the Report did not make strong enough recommendations to address the ship scrapping problem faced by the U.S. government. See **Congressional Issues** section.]

Among the recommendations affecting EPA are the following:

PCB Guidance

EPA and OSHA, along with Defense Logistics Agency (DLA), Navy, MARAD and interested parties, should develop guidance for testing, removal, and disposal of non-liquid PCBs in accordance with applicable rules and regulations.

Regulatory Oversight

EPA, Navy, MARAD and OSHA should enter into a cooperative agreement that would: provide notification to EPA when a ship scrapping contract is let and the location of the proposed scrapping operation; provide for EPA participation in post-award/pre-performance conferences at which environmental plans are reviewed; provide for sharing of compliance histories of prospective bidders on request of DLA or MARAD.

EPA and OSHA were encouraged to conduct joint compliance inspections.

EPA was encouraged to conduct comprehensive, multimedia, environmental inspections of ship scrapping operations.

EPA was encouraged to develop a compliance manual that outlines for ship scrappers the

relevant environmental requirements.

International Issues

EPA, Navy and MARAD agreed to revise the interim export Agreements to: expand notification regarding specific ships to include detailed information about the materials commonly found on these ships; revise the notification to include tacit agreement, if a country did not object to the export within 30 days of notification that a ship might be exported. EPA also agreed that we would review the export agreements annually to evaluate their use and determine whether they should remain in force.

EPA also agreed to work with Navy, MARAD, State, Commerce, Labor and AID to evaluate how meaningful technical assistance could be provided to interested importing countries, including whether current statutory authorities and funding are adequate for this purpose.

BACKGROUND:

- Under the current TSCA regulations, export of PCBs at concentrations of 50 ppm or greater for purposes of disposal is prohibited.
- In 1994, EPA proposed a rule to allow the export of PCBs for disposal. This rule would treat the transboundary movement of PCBs the same as the transboundary movement of other hazardous waste under RCRA.
- The EPA Agreements with the Navy and MARAD were intended to be interim agreements until the final rule covering the export of ships containing PCBs for scrapping is published. The Agreements include provisions requiring the removal from the vessels of liquid PCBs and non-liquid PCBs that are "readily removable" prior to export. They also require notification to importing countries, prior to export, regarding the vessel exporting program followed by notification of vessel-specific exports.
- The Agreements do not address the export of asbestos, lead, chromates and other toxins which may be present on these obsolete vessels. EPA interprets its regulations as not prohibiting the export for scrapping of asbestos. Export of lead is not prohibited, although waste materials containing lead may be subject to RCRA. Sodium chromate, which performs a ballast function, is not considered to be a waste at the time of export. Any materials which is not performing a function and which falls within RCRA's definition of "hazardous wastes" would potentially be subject to hazardous waste export controls.

Major Activities

- Work with Navy, MARAD, and OSHA to implement recommendations of Interagency Ship Scrapping Review Panel as appropriate.

APPENDIX F
NOVEMBER 30, 1995 LETTER TO MARAD



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

RECEIVED

DEC 5 1995 2:32

TOXICS ENFORCEMENT
SECTION 606-AT
OFFICE OF ALLAS, TX
ENFORCEMENT AND
COMPLIANCE ASSURANCE

November 30, 1995

Joan M. Bondareff
Chief Counsel
Maritime Administration
Room 7232, MAR-220
400 Seventh Street, S.W.
Washington, D.C. 20590

Dear Ms. Bondareff:

This letter finalizes EPA's May 5, 1995 interim response provided to Ms. Erin Anderson, Esq. and supplements the May 16, 1995 EPA letter which responded to your May 9, 1995 request for clarification.

In general, EPA has determined that MARAD has adequately addressed EPA's main concerns in its counter-proposal dated April 28, 1995. Those concerns include (1) financial assurance in the event that the purchaser or scrapper is unwilling or unable to remove and properly dispose of PCB waste from the vessels; (2) removal and disposal of PCB waste in accordance with 40 CFR Section 761 prior to smelting operations or export of the ship carcass; (3) final inspection of the vessel in the event that it is exported for scrap recycling (disposal) and (4) EPA notification.

This letter applies only to the two vessels, the Northwind and the Santa Isabel listed in your Attachment A (Enclosure 1), which are subject to the Invitation for Bid (IFB), EXC-8633 dated January 13, 1995. It is EPA's understanding that these vessels are to have the PCBs removed within the EPA Regions of 3, 4, or 6. As such, the terms and conditions included in this letter have been reviewed by these EPA offices and are only applicable to locations within these three regions. EPA and MARAD will negotiate a more comprehensive compliance agreement for future distribution of auctioned vessels.

Financial Assurance

EPA has determined that, for the purpose of the referenced transfers, the amount of the \$75,000 performance bond from the purchaser, set aside for PCB cleanup, is acceptable financial assurance when combined with MARAD's self-insurance and status as

a generator. Please provide the EPA with a copy of the performance bond.

EPA has determined that MARAD is a generator of the PCB waste on its surplus vessels. This potential liability that MARAD retains as a generator, coupled with self insurance (and the performance bond) provides adequate assurance that the ultimate disposition of PCBs and PCB items in concentrations of 50 ppm or greater on board the two (2) vessels listed in your Attachment A will be in accordance with the regulations at 40 CFR 761.

While MARAD retains generator liability, EPA is willing to accept MARAD's proposal that it and the scrapper/PCB removal performer share co-generator status for any PCB waste which results from ship scrapping operations. Whether or not EPA accepts this co-generator arrangement for future sales is yet to be determined. The October 28, 1993 letter from Tony Baney (EPA) to Iona Evans (Navy) is enclosed (Enclosure 2) and EPA has determined that similar co-generator status will be applicable to the sale of the two vessels noted in Attachment A of MARAD's April 28, 1995 letter. MARAD designated co-generators must have EPA TSCA generator ID numbers.

Designation of the Shipyard as a Temporary Storage Facility

EPA can not agree to designate either the ship or the shipyard as a PCB temporary storage facility under 40 CFR 761.65 (c).

The discussion concerning storage requirements from EPA's response to your May 9, 1995 fax is restated here: As a matter of enforcement discretion and not regulatory interpretation, EPA has determined that a storage-for-disposal clock should begin to run from the time that the PCBs and PCB items are removed from their existing use and location on the vessel. The removal of the items (from their present use and location on the vessel) would trigger a one year storage for disposal time period. By the end of that year, these items must have been disposed of. For example, if the scrapper/PCB remover chose to remove and then store PCB items for almost one year, by the 365th day after removal, the item must be disposed of in a TSCA landfill or incinerated in accordance with the PCB regulations.

As a matter of enforcement discretion and not regulatory interpretation, non-liquid PCBs and PCB items which are removed from the vessel must be stored in compliance with 40 CFR 761.65 (b)(1)(i) which is the requirement that a storage facility shall have an adequate roof and walls to prevent rain water from reaching the stored PCBs and PCB items. The other provisions of 761.65 (b) do not have to be adhered to for non-liquid PCBs removed from these two vessels.

Non-liquid PCB items which are removed from their present location on the vessel may be stored on the vessel itself in covered waterproof containers. If liquid PCB waste is to be stored, it must be stored on or off the vessel in conformity with 40 CFR 761.65 (b) (except for the flood plain requirement). Liquid waste may not be stored for longer than a 30 day period if it is stored in a flood plain. The goal of these requirements is that PCBs and PCB Items be handled and stored in a manner that prevents migration or release of the PCBs into the environment.

Removal of PCBs from the Vessel

PCBs at concentrations equal to or greater than 50 ppm are regulated for disposal. Consequently, any PCB material on the vessel at 50 ppm or greater must be removed and disposed of in accordance with 40 CFR 761 prior to export of the vessel for demolition/scrap. Even if the vessel is not exported, this PCB material must be disposed of in accordance with the regulations.

EPA's April 14, 1995 draft proposal listed those items on old vessels which are presumed to contain PCBs. They are:

- cable insulation
- rubber gaskets
- felt gaskets
- thermal insulation material
 - fiberglass
 - felt
 - foam
 - cork
- transformers
- capacitors
- electronic equipment with capacitors and transformers inside
- adhesives
- tapes
- oil
 - electrical equipment and motors
 - anchor windlasses
 - hydraulic systems
- surface contamination of machinery and other solid surfaces (unknown sources presumably from historic practices)
- oil-based paint¹

¹ Oil-based paint will be treated the same as other suspect materials, i.e. it will be presumed to be contaminated with PCBs at concentrations equal to or greater than 50 ppm (particularly paint in cans) unless sampling and testing results show a lesser concentration, and shall be removed and disposed of in accordance with 40 C.F.R. Part 761 with the following exceptions:

- caulking
- rubber isolation mounts
- foundation mounts
- pipe hangers
- light ballasts
- any plasticizers

This list is supplemented by the enclosed Department of Justice letter (Enclosure 3) which contains a similar list. Please be advised that applicability of the PCB regulations is not necessarily restricted to items on the list. All PCBs at concentrations of 50 ppm or greater are regulated for disposal.

Domestic - Paint which is contaminated with PCBs is not required to be removed from any painted surface from either ship which is to be smelted in the United States, provided that it will be smelted in a device which meets the definition of "industrial furnace" as defined in 40 C.F.R. 260.10.

International - Paint which is contaminated with PCBs is not required to be removed from any painted surface from either ship which is to be sent to a foreign country for smelting, provided that the following conditions are observed:

(1) At least 90 days prior to export of the ships, notice is given by EPA to the importing country of the intended export. This notification will state (a) that the ships in question may contain PCBs in concentrations of 50 ppm or greater, (b) the conditions for export contained in this letter, and (c) that the export will be authorized if the importing country consents in writing to the export, or does not object in writing to the export within 90 days of the date of the notification. Export of the ships may not proceed until (i) written consent of the importing country is received by EPA, or (ii) 90 days have elapsed from the date of notification of the export and the importing country has not objected.

(2) The contract between the exporter and the importer/disposer specifies that the material will be handled in an environmentally sound manner;

(3) The exporter or MARAD or its cogenerators shall take back the materials or make alternative arrangements to ensure their environmentally sound management if: they are sent without notice and opportunity to object as specified above; consent was obtained through falsification, fraud or misrepresentation; or the materials cannot be handled in accordance with the terms of the contract.

The lists are supplied to provide guidance concerning those items that EPA presumes to be contaminated with PCBs at regulated levels.

Purchasers/PCB removers may approach PCB remediation in one of the following ways:

(1) Purchasers/PCB removers may assume that the items on this list are contaminated with regulated PCBs which must be removed and disposed of in accordance with the PCB regulations; or

(2) Purchasers/PCB removers may undertake sampling analysis to disprove the presumption that the suspect items contain regulated PCBs; or

(3) Purchasers/PCB removers may elect to remove all of one item type (ie: felt gaskets) and elect to conduct sampling analysis on another item type (ie: electrical cables).

To assist the purchaser/PCB removers who desire to sample the suspect material, EPA has developed a guidance which addresses PCBs in ship disposal operations. This guidance (Enclosure 4) provides the national policy on sampling and/or removal expected from ship disposal (including scrapping) operations. The PCB removers/purchasers for the Northwind and the Santa Isabel shall utilize the guidance in their ship scrapping activities should they desire to sample items presumed to contain regulated PCBs. The guidance was developed as a generic guide. In any instance where the terms and conditions of this letter may conflict with the guidance, the provisions in this letter shall be controlling. Any questions concerning implementation of the guidance should be directed to the appropriate EPA office.

Certification of PCB Removal

EPA requires a certification from the President or CEO of the PCB Remover/Scrapper that the successful removal and proper disposal of all PCBs and PCB Items with a concentration of 50 ppm or greater on board this vessel(s) has been accomplished. The certification shall include statements that:

- all known PCB liquids at concentrations of 50 ppm or greater have been removed;
- any liquids which have not been removed which could contain PCBs based on their use have been analyzed for PCBs and found to be less than 50 ppm and are not the result of dilution following the sale of the ship;
- all items listed in each category have been removed and disposed of in accordance with 40 CFR subpart D, or representative sampling conducted in accordance with Enclosure 4 indicated that the items did not have to be

removed because PCB levels were below 50 ppm.

- I certify under penalty of the law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate information. Based upon my inquiry of the person or persons directly responsible for gathering information, the information is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for falsifying information, including the possibility for fines and imprisonment for knowing violations. Dated: _____ Signature: _____ Title: _____

Complete copies of all sampling results and manifests signed by the first transporter for PCB waste transported for disposal shall be provided to EPA as an attachment to the certification.

In the event that any portion of the vessel will be exported for disposal, this certification must be received by the appropriate EPA regional contact at least 15 calendar days prior to export of the vessel(s). In addition, at least 30 calendar days prior to export, the scrapper/PCB remover shall transmit to the appropriate EPA regional contact the sampling and analysis results for all samples taken to verify the concentration of PCBs and PCB Items.

The minimum information required for each sample listing is: a unique sample identification number; the location (including deck) where the sample was taken; the kind of material or item sampled and the amount of sample taken; the distance from the bow of the ship to the sample location; the date and the time that the sample was collected; the name and phone number of the sample collector; the PCB concentration in the sample; the limit of quantitation for the chemical analysis; the extraction method used including the identity of any solvents; and the EPA-approved analytical method used for chemical analysis. In addition, the chain of custody form(s) and at least 10% of the chromatograms shall be submitted to EPA. Of course, the EPA Regional Office where the PCB sampling/removal occurs, can and may request additional information as deemed necessary.

At least 30 calendar days prior to export, the purchaser/PCB remover shall transmit to the appropriate EPA regional contact complete copies of all manifests signed by the first transporter for PCB waste transported for disposal.

Notification Provided to EPA by MARAD or Their Co-Generators

All notification requirements are to be provided to the EPA Regional PCB Contacts in the regions where the PCB removal will take place and a copy shall also be submitted to EPA HQ. The points of contact are:

USEPA Region 6
Lou Roberts (6EN-AT)
Toxics Section
1445 Ross Avenue, Suite 1200
Dallas, TX 75202-2733
phone: 214-665-7579 fax: 214-665-7446

USEPA Region 3
Ed Cohen
841 Chestnut Building
Philadelphia, PA 19107
phone: 215-597-7668 fax: 215-597-3156

USEPA Region 4
Stuart Perry
345 Courtland Street, N.E.
Atlanta, GA 30365
phone: 404-347-3222 (x6907) fax: 404-347-1681

USEPA HQ
Diane Lynne
Federal Facilities Enforcement Office (2261)
401 M Street, SW
Washington, D.C. 20460
phone: 202-260-9755 fax: 202-260-9437

MARAD and/or its co-generators must perform all generator duties listed in the PCB regulations, including the notification and manifesting requirements at 40 CFR 761. In addition, MARAD and/or its co-generators shall transmit to EPA a floor plan map of each deck of both vessels, a plan with respect to the removal and/or a complete sampling, and characterization for PCBs, a schedule for PCB removal, notification of where the PCB removal will take place and when the vessel will be transferred from MARAD. MARAD shall provide EPA with a copy of the contract between both MARAD and the purchaser and between the purchaser and the scrapper/PCB remover (if available). MARAD shall provide EPA with a contact person, phone and fax number for each business entity listed on Attachment A as well as the MARAD point of contact for these PCB removal operations. This information must be provided to EPA as soon as possible after acceptance of the bid, but no later than two weeks prior to delivery of the vessel to the PCB removal location.

EPA acknowledges that via "Article 14, Environmental Pollution" of the proforma Contract contained in the Invitation for Bid package, MARAD has notified the bidders of the potential locations of PCBs on board the vessels and of the applicability of the federal PCB regulations at 40 C.F.R. Part 761.

MARAD shall notify the EPA Regional office in writing if MARAD becomes aware of any violations of 40 C.F.R. Part 761.

Either MARAD or their co-generators shall provide notification to the dock owner that PCB removal/storage activities will be conducted at that site. A copy of this notification shall be sent to EPA.

Inspection of PCB Removal

In the event that the purchaser proposes to export the hulk of the vessel, MARAD, or its contract inspector, will conduct a final audit inspection of the vessel after the purchaser has represented to MARAD that all PCBs equal to or greater than 50 ppm have been removed and disposed of properly. The final audit inspection shall include a visual inspection of the areas suspected to contain PCBs to ensure that those items have been removed. The audit will also include a visual inspection of all areas separate from the vessel where PCB waste has been stored prior to transportation off-site for disposal, if any. In order to conduct a visual inspection acceptable to EPA, areas where PCBs are normally expected to be found (such as behind walls and above ceiling tiles) shall be visually accessible for inspections. If the visual inspection reveals potential PCB objects on the vessel or in storage areas, MARAD will confirm by review of the test/sampling data, that the remaining items contain PCBs in concentrations of less than 50 ppm. In the event that the review of the test/sampling data indicates that the remaining potential PCB objects either contain PCBs at concentrations of 50 ppm or greater or were not adequately tested, the purchaser will be required to either remove or test the remaining potential PCB objects. Following the removal or testing of these remaining potential PCB objects, MARAD shall conduct another visual inspection of the vessel. A written audit report which outlines the results of the audit(s) shall be provided to the EPA regional office at least 7 calendar days prior to the export of the vessel.

Asbestos and Lead-related Issues

If the two vessels contain asbestos and/or lead and if such asbestos and/or lead will be disposed of and/or recycled during the anticipated disposal/recycling operations in the importing country, then the conditions identified in the paragraphs numbered 1-3 under "International" issues in footnote 1, above, must also be applied to the asbestos and lead on the vessel. These notification and opportunity to object procedures may be handled concurrently for PCBs, asbestos and lead.

Within the United States jurisdiction, asbestos, lead and any other regulated substances (except for PCBs to the extent that they are specifically addressed in this letter) shall be handled in accordance with all the applicable U.S. laws and regulations including, if appropriate, the NESHAP requirements.

Within the U.S., the Asbestos National Emission Standard for Hazardous Air Pollutants (NESHAP) applies to regulated facilities undergoing a demolition or renovation where asbestos containing material will be disturbed or damaged. A ship is considered to be a regulated facility under the definition of a facility (40 CFR Part 61 subpart M). The scrapping of a vessel within the United States, is considered to be a demolition which at the very least requires a notification to U.S. EPA or its delegated agent under Section 40 CFR 61.145.

Enforceability

By awarding contracts for the two vessels discussed in this letter, the Northwind and the Santa Isabel, MARAD agrees to the terms and conditions contained in this letter of enforcement discretion. This letter is not and shall not be construed to be a vehicle to relieve MARAD and its co-generators of any legal or regulatory obligations including obligations under any environmental laws or regulations except as expressly provided for herein. In the event that MARAD fails to comply with any of its obligations under this agreement and the parties are unable to resolve the issue informally, EPA reserves any rights granted to it under applicable law to seek administrative or judicial relief against MARAD. Where this letter requires a specific action, certification or notification from the purchaser/scrapper/PCB remover, MARAD shall notify the purchaser in writing of such requirements through either the proforma Contract contained in the Invitation for Bid package, the conditional award letter, the contract for sale, or any other legally enforceable mechanism.

Please call Diane Lynne of my staff at 202-260-9755 if you require additional clarification.

Sincerely,



Barry N. Breen
Director

Federal Facilities Enforcement Office

Four Enclosures:

- (1) MARAD Attachment "A", NORTHWIND and SANTA ISABEL particulars (1 page);
- (2) October 28, 1993 letter from Tony Baney (EPA) to Iona Evans (NAVSEA) re: co-generator status (2 pages);
- (3) April 21, 1995 DOJ letter re: Guidance for Evaluation and Cleanup of PCBs on Board the USS Cabot/Dedalo (3 pages);
- (4) EPA Guidance on ship scrapping; "Sampling Ships for PCBs Regulated for Disposal, November 30, 1995 (21 pages).

cc: Mike Stahl (OECA)
Jesse Baskerville (OECA-TEPD)
John Smith (OPPTS)
Roland Dubois (OGC-Toxics)
Joe Freedman (OGC-International)
Tom Sullivan (OCLA)
Lou Roberts (EPA Region 6)
Ed Cohen (EPA Region 3)
Stuart Perry (EPA Region 4)
Trigg Talley (State)

Enclosure I

ATTACHMENT "A"

MARAD VESSELS PROPOSED TO BE SOLD

| | | |
|-----------------------|---|--|
| Vessel Name | NORTHWIND | SANTA ISABEL |
| Present Location | Fort Eustis, VA | Fort Eustis, VA |
| Lightship Weight | 3,495 long tons | 9,948 long tons |
| Proposed Purchaser | Transform Marine, Inc. 641 S. Port Road Brownsville, TX 78523 | Rig Ventures, Inc. 6665 E. 14th Street Brownsville, TX 78520 |
| Purchase Price | \$241,900 | \$497,900 |
| PCB Removal Performer | Transform Marine (Address same as above) EPA ID No. TXD988042131 | Baltimore Resources, Inc. 1840 Frankfur Avenue Baltimore, MD 21226 EPA ID No. MD0001096841 |
| Storage/Disposal Site | Rollins Environmental Services 2027 Battleground Road Deer Park, TX 7753 EPA ID No. TXD055141378 and/or U.S. Ecology P.O. Box 576 Beatty, NV 89003 | CVM Chemical Services, Inc. 1350 Balmer Road Model City, NY 14107 EPA ID No. NYD049836679 |
| Transporter | Hud City Environmental, Inc. Houston, Texas EPA ID No. TXD988084398 | Chemical Waste Management, Inc. 4400 River Road Tonawanda, NY 14150 EPA ID No. ILD099202681 |
| Sampling Analyst | Pen American Labs 5337 East 14th Street Brownsville, TX 78521 | Environmental Reference Laboratory 1901 Sulphur Spring Road Baltimore, MD 31227 |
| MARAD Surveyor | Halliburton MUS Corp. via subcontractor MSCL Inc. 1452 Duke Street Alexandria, VA 22314-3458 | Halliburton MUS Corp via subcontractor MSCL Inc 1452 Duke Street Alexandria, VA 22314-3458 |
| PCB Removal Location | Brownsville, TX | Wilmington, NC or Brownsville, TX |

Nov. 29, 1995

NWMAR117839



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OCT 28 1993

OFFICE OF
PREVENTION, PESTICIDES
AND TOXIC SUBSTANCES

Iona E. Evans
Department of the Navy
Naval Sea Systems Command
2531 Jefferson Davis Highway
Arlington, VA 22242-5160

Dear Ms. Evans:

I am responding to your September 2, 1993 letter to Mr. Tad McCall, Acting Deputy Assistant Administrator for Federal Facilities Enforcement. In that letter, you requested that EPA's Toxics Enforcement Committee evaluate the Navy's request to allow its contractors to perform the generator duties associated with the disposal of PCB waste resulting from the scrapping and recycling of decommissioned Naval vessels. Although the Toxics Enforcement Committee did not review your request during their monthly meeting, representatives from the Office of Pollution Prevention, and Toxics, (OPPTS), the Office of Compliance Monitoring (OCM), the Toxics Litigation Division (TLD), the Office of General Counsel (OGC), and the Office of Federal Facilities Enforcement (OFFE) have discussed your request and have reached a decision concerning the generator issue.

Based on the facts as presented in your September 2, 1993 letter, EPA has decided that it is appropriate to view the Navy and its contractors as co-generators of any PCB waste which results from ship scrapping operations. Accordingly, EPA is now proposing incorporation of the following provision addressing scrapping in the Compliance Agreement:

On behalf of the Navy, the Defense Reutilization Marketing Service ("DRMS") sells some excess USN titled vessels to private industry for the purpose of disposal of the vessels by scrapping. The Navy shall provide full notice through DRMS to bidders on contracts for the scrapping of those vessels, of the Navy's knowledge of the existence of PCB items and potential PCB items on board those vessels and shall require such transferees to acknowledge their duty to comply with the requirements of TSCA and 40 C.F.R. Part 761. The contract shall provide that the Navy and the transferee will perform all required duties, including those of the generator of PCB waste, for any PCB items that are removed from the vessel. The contract shall specify which duties such as manifesting, record-keeping, annual reports, etc..., will be performed by the Navy and/or the transferee as co-generators.

EPA's decision to treat the Navy as a co-generator of PCB waste, rather than the sole generator, obviates the need for ship scrappers who are co-generators from applying for and receiving approvals as commercial storers. The draft language does not eliminate any other regulatory requirements such as the current need to obtain disposal permits (40 CFR 761.60) for the chopping, stripping or otherwise processing of unauthorized wire cabling containing PCBs.

You have requested that "the Navy be permitted to proceed with its ship scrapping program with the contractor acting as and performing all generator duties." The new draft provision offered by EPA allows the Navy and its scrappers to determine contractually which party will perform the various generator-specific duties, while acknowledging the generator status of each. In the interests of expediting Navy surface vessel scrapping activities, EPA is amenable to the immediate application of the proposed paragraph pending execution of a final compliance agreement. The terms and conditions set forth in the executed compliance agreement will, of course, supersede the draft language offered in this letter.

If you have any questions concerning this letter, please call me at (202) 260-3933. Questions concerning the compliance agreement should be directed to Diane Lynne at (202) 260-9755.

Sincerely,



Tony Baney, Chief
Operations Branch

cc: Barry Breen, OFFE
Mike Walker, OE
Mike Stahl, OCM
Mike Wood, OCM
Pat Roberts, OGC
PCB Coordinators, Regions I-X
PCB Branch Chiefs, Regions I-X
Federal Facility Coordinators, Regions I-X

Enclosure

3



U.S. Department of Justice

Environment and Natural Resources Division

OPTIONAL FORM 99 (7-90)

FAX TRANSMITTAL

of pages = 4

| | |
|------------------------|-------------------------|
| To: Diane Lynne | From: Jim Curtin |
| Dept./Agency | Phone # |
| Fax # | Fax # |

GEN 7542-01-317-7366 5099-101 GENERAL SERVICES ADMINISTRATION

Environmental Enforcement Section
P.O. Box 7611
Washington, D.C. 20044-7611

Pub. (202) 333-3333
Fax (202) 333-3333

April 21, 1995

BY FACSIMILE TRANSMISSION

**George D. Fagan
Leake & Anderson
Attorneys at Law
1700 Energy Centre
1100 Poydras Street
New Orleans, Louisiana 70163-1701**

**Re: Guidance for Evaluation and Cleanup of Polychlorinated
Biphenyls (PCBs) on Board the USS Cabot/Dedalo**

Dear Mr. Fagan:

This letter is intended to provide guidance for the USS Cabot/Dedalo Museum Foundation, Inc. ("Foundation") to successfully remove and properly dispose of all PCBs and PCB items at concentrations of 50 ppm or greater from the ex-USS Cabot/Dedalo ("vessel") in accordance with the PCB regulations at 40 C.F.R. Part 761, and Judge McNamara's March 30, 1995 order.

As you know, EPA very is concerned about the documented spill of oil on the floor of a Mooring/Windlass Room where a sample indicated a PCB content of 275 parts per million (ppm). This spill should be properly addressed in accordance with 40 C.F.R. Part 761 which includes identifying the source. EPA is also concerned about the other oil leaks that were noted by the EPA Inspectors on December 14 and 15, 1994. These leaks and all other spills involving PCBs with a concentration of 50 ppm or greater must also be properly remediated in accordance with 40 C.F.R. Part 761 which, again, includes identifying the source.

EPA presumes that the following list of items contain PCBs at concentrations of 50 ppm or greater. This list includes those items that have been found to contain PCBs on board naval vessels:

- electrical cable
- Rubber gaskets
- felt gaskets
- thermal insulation material

- fiberglass
- felt
- foam
- cork
- transformers
- capacitors
- electronic equipment
 - With capacitors and transformers inside
- voltage regulators
- switches
- reclosers
- bushings
- electromagnets
- adhesives
- tapes
- oil
 - electrical equipment and motors
 - anchor windlasses
 - hydraulic systems
 - leaks and spills
- surface contamination of machinery and other solid surfaces
- oil-based paint
- caulking
- rubber isolation mounts
- foundation mounts
- pipe hangers
- light ballasts
- any plasticizers

The Foundation may elect to presume, as EPA does, that all the items listed above contain PCBs with a concentration of 50 ppm or greater, and remove and dispose of these items in accordance with 40 C.F.R. Part 761. Or, the Foundation may elect to conduct a comprehensive Environmental Assessment ("EA") on board the vessel for PCBs and then remove those actual items found to contain PCBs with a concentration of 50 ppm or greater.

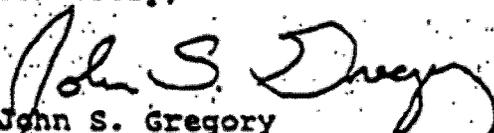
If the Foundation chooses to conduct a comprehensive EA for PCBs (which must include the many areas of the vessel where doors and hatches have been bolted shut) instead of presuming that the above listed items contain PCBs with a concentration of 50 ppm or greater, the sampling must be conducted in accordance with EPA published guidance. Records of all sampling and analysis must be retained for EPA inspection.

¹ EPA requires that electrical cable samples be separated into their individual components (i.e., paint, paper, plastic, material around copper wire, copper wire casing, outer covering (casing), gummy material, plastic wrap, etc.) and be analyzed separately.

EPA is willing to review a complete sampling, characterization, and removal plan (including an identification of specific extraction and analytical methods to be used in all sampling) prior to commencement of any activity.

Please be advised that EPA intends to inspect the vessel upon completion of the Foundation's remedial activities for the purpose of providing information to the Court at the contradictory hearing ordered by Judge McNamara in his March 30, 1995 order.

Sincerely,



John S. Gregory
United States Department of Justice
Environmental Enforcement Section
Environment and Natural Resources
Division

Ph. (202) 514-1134
Fax (202) 514-8395

cc: Via Telefax

Mike Zevenbergen, Esq.
Environmental Defense Section
U.S. Department of Justice
(202) 514-2584

Lynda F. Carroll, Acting Director, Air, Pesticides & Toxic
Division, Region 6, Environmental Protection Agency
Bernard J. Klein, Klein Ainsworth & Company, Inc.
Alexander Sheffield, III - Chairman, USS Cabot/Dedalo
Museum Foundation, Inc.

ENCLOSURE 4

November 30, 1995

SAMPLING SHIPS FOR PCBs REGULATED FOR DISPOSAL (Interim Final Policy)

I. Introduction

At the request of the United States Environmental Protection Agency's (EPA's) Federal Facilities Enforcement Office and the EPA Regional PCB Coordinators, this technical policy document was prepared by the Operations Branch in the Chemical Management Division in the Office of Pollution Prevention and Toxics to provide an interim method of determining whether polychlorinated biphenyls (PCBs) have been removed from ships (vessels).

II. Purpose

This policy addresses management of PCBs and/or PCB items regulated for disposal known or suspected to be on board vessels destined for scrapping for purposes of metal recovery/recycling. This guidance is self-implementing. There are notification and recordkeeping requirements, however, no EPA PCB disposal approval is required to carry out the PCB removal procedures as part of a scrapping procedure. EPA may determine that information sent in the notification is incomplete and retains the right to request complete information as required in the notification.

This policy provides two options for shipbreakers or scrappers to remove PCBs from a vessel:

- (a) All known sources of liquid PCBs, defined in IV.(a) below, and all known uses of non-liquid PCBs, defined in V.(a) below are removed. No sampling or measurements are required for this removal.

(b) Use this policy to sample the vessel and chemically analyze the samples for the presence of PCBs to determine whether PCBs at concentrations regulated for disposal are present on the vessel. Scrappers can opt either to:

- (i) sample all items suspected to contain PCBs in all classes of uses of non-liquid PCBs (called Strata in VI.c.(ii)(B)(2)(c) below); or
- (ii) in place of sampling and analysis of items in all classes of known uses of PCBs, scrappers may utilize this policy to remove some classes of uses of non-liquid PCBs and sample all other classes.

As an example of II(b), assume that for economic reasons, a scrapper decided to remove and dispose of as PCB waste all electrical cable, because in his/her experience a sufficient proportion of the cable is regulated for disposal. The decision was based on the expense of sampling and analysis which would only confirm that all cable would be regulated. Another similar reason to support this decision is that the sampling and analysis costs to determine which cable was regulated exceeded the economic benefit from identifying regulated and non-regulated cable. Once the electrical cable was removed and disposed of as regulated PCBs, the scrapper would still be required to either remove all other known classes of uses (air handling system gaskets and other known uses [other than cable and air handling gaskets]) or sample to determine whether there were regulated PCBs in these other known classes of uses of non-liquid PCBs.

This policy does not address any other potentially regulated material such as asbestos, lead, or any material considered hazardous under the Resource Conservation and Recovery Act.

III. Notification

- (a) At the point of sale of a vessel, which will undergo PCB removal prior to scrap metal recovery, the seller (for Federal Government owned vessels, the seller is usually the Defense Reutilization and Marketing Service, the

Maritime Administration, or the General Services Administration) of a vessel for scrap metal recovery shall notify the EPA Regional PCB Coordinator where the vessel is berthed at the time the bid is accepted, of: (i) the time the vessel will be moved from its storage berth to the PCB removal point or storage point prior to PCB removal, and (ii) the intended future location of storage prior to PCB removal and the PCB removal location.

(b) At the point of sale, the purchaser of the vessel, which will undergo PCB removal, shall notify the EPA Regional PCB Coordinator(s), where the vessel will be located prior to and during PCB removal as part of the overall scrap metal recovery process. The notification shall include:

(i) the date the ship will be moved from the berth at the time of sale to any temporary storage berth prior to PCB removal and the date the vessel will be moved from the temporary storage location to the location where PCB removal will occur prior to and/or during scrap metal recovery;

(ii) the location(s) of storage and PCB removal;

(iii) the date of arrival at that (those) location(s);

(iv) the proposed time period of the storage, PCB removal, and metal recovery activities;

(v) the business address and phone number of a responsible party from the seller's office who can provide the status of the sale, PCB removal activities, and scrap metal recovery activities; and

(vi) the business address and phone number of a responsible party from the purchaser of the vessel and/or the PCB removal company who can provide information on the status of the PCB removal activities.

(c) Thirty calendar days before starting the PCB removal activity from a vessel, a scrap metal recovery company and/or PCB removal company shall provide the EPA Regional PCB Coordinator(s) where PCB removal will occur, with:

- (i) A map showing the location of the storage facility and PCB removal location;
- (ii) The PCB removal plan which includes details on the identification of known sources of PCBs on the vessel.
- (iii) A floor (deck) plan for each deck of the vessel showing the location(s) of PCBs to be removed; and
- (iv) The schedule for removing PCBs from the ship, including:
 - (A) the estimated date that all PCBs will be removed from the ship;
 - (B) the estimated date all PCBs greater than or equal to (\geq) 50 parts per million (ppm), which are removed from the ship and placed in storage, will be removed from storage and sent for PCB disposal;
 - (C) disposal method and company to be used for each kind of PCB waste > 50 ppm, and
 - (D) the PCB removal equipment decontamination procedures and schedule.
- (d) At any time, EPA inspectors shall have the option of inspecting any vessel during a PCB removal activity.

IV. Liquid PCBs

(a) Known sources of Liquid PCBs

Known sources of liquid PCBs potentially on board vessels are: electrical equipment - including transformers, capacitors, fluorescent light ballasts, voltage regulators, circuit breakers, liquid-filled cable, reclosers, rectifiers; hydraulic equipment; heat transfer fluids; vacuum pump oil; air compressor lubricants; cutting oil; and grease.

(b) Management and Disposal of Liquid PCBs

(i) Prior to beginning scrap metal recovery and non-liquid PCB removal operations, all PCB items or equipment on board the vessel containing liquid PCBs at concentrations ≥ 50 ppm shall be removed from the vessel and be disposed in accordance with the PCB disposal regulations at 40 CFR 761 Subpart D. Accumulations of small capacitors present in fluorescent light ballasts and electronic equipment, which may be disposed of as municipal solid waste under 40 CFR 761, disposal of these items also may be addressed under the Comprehensive Environmental Response, Compensation, and Liability Act minimum reportable disposal quantity regulations.

(ii) Impervious solid surfaces, (as defined at 40 CFR 761.123) which are contaminated with liquid PCBs, shall be cleaned to less than 100 micrograms per 100 centimeters square ($< 100 \mu\text{g}/100 \text{cm}^2$) PCBs if the material beneath the surface is to be smelted in a smelter meeting the definition of an industrial furnace in 40 CFR 261.10. If the material beneath the surface is not going to be smelted, then the surface shall be cleaned to $\leq 10 \mu\text{g}/100 \text{cm}^2$.

(iii) Non-impervious solid surfaces, (as defined at 40 CFR 761.123) which are contaminated with liquid PCBs, shall not be evaluated for PCB removal by a surface sampling test, but cleaned to < 50 ppm, as measured by a core or scrape sample, if the solid beneath the surface will be recycled by smelting in a smelter meeting the definition at 40 CFR 261.10. If the solid beneath the surface will be recycled but not smelted in a smelter meeting the definition at 40 CFR 261.10, the PCB cleanup level is < 2 ppm, as measured by a core or scrape sample.

V. Non-Liquid PCBs

(a) Known Sources of Non-Liquid PCBs

Known sources of non-liquid PCB materials in vessels are non-conducting materials in electrical cables (such as plastic and rubber), gaskets in air handling systems, other rubber gaskets, other felt gaskets, thermal

insulation material (including fiberglass, felt, foam, and cork), sound deadening felt, oil-based paints, grouting/caulking, adhesives, tapes, rubber isolation mounts, foundation mounts, pipe hangers, rubber/plastic parts of all sizes and shapes, and any other materials where plasticizers were used.

(b) Management and Disposal of Non-Liquid PCBs

(i) The concentration of PCBs in electrical cable shall be based on the concentration of PCBs in each non-metal, non-liquid component of the cable individually. The concentration of PCBs in electrical cable shall not be based on the total weight of PCBs in the cable divided by the total weight (a) of all non-metal components, (b) of all metal components, or (c) of all non-metal and metal components. If one non-metal component of the cable is regulated for disposal, the entire cable is regulated for disposal. Separation of PCB materials (≥ 50 ppm PCBs) from non-PCB materials (less than 50 ppm PCBs) for purposes of disposal of PCBs and/or deregulation of metal (for purposes of PCB disposal) shall be in accordance with the approval requirements in 40 CFR 761 Subpart D. PCBs ≥ 50 ppm which are removed from the vessel are regulated for disposal and are subject to the requirements for storage and disposal at 40 CFR 761 Subpart D. Disposal approvals may consider the determination of PCB disposal status of non-liquid PCBs based on a measurement of processed cable aggregate rather than individual cable components.

(ii) For purposes of this policy, paints and other thin coatings on metal will not be required to be removed if the coated metal will be smelted domestically in a smelter meeting the definition of an industrial furnace at 40 CFR 261.10. For smelting outside the United States, export of the vessel having these metal coatings shall be pursuant to an EPA enforcement agreement.

VI. Sampling to Verify that PCBs Have Been Removed from a Vessel

In the event that all of the following known sources of non-liquid PCBs:

non-conducting materials in electrical cable; gaskets in air handling systems, rubber gaskets (other than gaskets in air handling systems), and

felt gaskets (other than gaskets in air handling systems); thermal insulation material (fiberglass, felt, foam, cork, etc.); sound deadening felt; oil based paints in containers (not paint applied to surfaces of the vessel); grouting/caulking; adhesives; tapes; rubber isolation mounts; foundation mounts; and pipe hangers;

have not been removed from a vessel, as an option to avoid sampling requirements prior to scrapping, the following plan shall be used to sample a vessel to verify that there are no PCBs in these applications at concentrations ≥ 50 ppm. EPA has not designated a process or method for removal of PCB uses from a vessel. In Appendix 1, EPA has designated and required the chemical analysis including extraction procedures. These procedures shall be used to determine PCB concentrations for verifying that there are no PCBs at concentrations ≥ 50 ppm remain on the vessel, either after removal of PCBs or verifying an assumption that no PCBs need to be removed as required in this policy. These same procedures shall be used for determining PCB concentrations for purposes of identifying disposal status with respect to 40 CFR 761.

(a) Certification

(i) Certification for domestic scrapping.

The President or CEO of the PCB removal and/or scrapping company shall certify that successful removal and proper disposal of PCBs and PCB Items with a concentration of 50 ppm or greater on board the vessel(s) has been accomplished. the certification shall include statements that:

(A) All known PCB liquids at concentrations of 50 ppm or greater have been removed;

(B) Any liquids which have not been removed, which could contain PCBs based on their use, and which are not the result of dilution following the sale of the ship, have been analyzed for PCBs and found to be less than 50 ppm;

(C) All items listed in each category have been removed and disposed of in accordance with 40 CFR Subpart D, or representative sampling conducted in accordance with this policy indicated that the items did not have to be removed because PCB levels were below 50 ppm.

(D) Records and documentation of sampling and analysis will be maintained for five calendar years at the scrapping location following completion of the last chemical analysis or the day of the last PCB removal activity which ever is later. In the event that the scrapping company, which is keeping these documents and records, ceases business operations before the end of the five year period, the records and documentation shall be sent to the EPA Regional PCB Coordinator. In the event that a PCB removal company changes address or becomes part of another company, the PCB removal company shall notify the EPA Regional PCB Coordinator of any new location where the records and documentation will be kept.

(E) Copies of all manifests signed by the first transporter for PCB waste transported for disposal shall be provided in the certification.

(F) The certification statement shall include the following language:

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate information. Based on my inquiry of the person or persons directly responsible for gathering information, the information is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for falsifying information, including the possibility for fines and imprisonment for knowing violations. Dated: _____ Signature: _____
____ Title: _____.

(ii) Certification for scrapping outside the customs territory of the United States

Certification for scrapping outside the customs territory of the United States shall be accomplished through a compliance agreement with EPA.

(b) Records of the Sampling and Analysis Results

The sampling and analysis results for all samples taken to verify that PCBs have been removed shall be maintained for EPA inspection. Results should be listed two ways: by individual sample and by sampling scheme stage (how the sample was selected in the sampling plan).

The information required for each individual sample listing is at a minimum: a unique sample identification number; the kind of material or item sampled; the location where the sample was collected (the deck on the vessel and frame number or the distance from the bow of the vessel to the sample location); the date the sample was collected; the sample collector; the amount of sample collected; the analytical procedure used; the PCB concentration in the sample; and the limit of quantitation for the chemical analysis.

For each step in the sample selection process the unique samples selected shall be listed in categories according to the outline of VI.c.(ii)-(iv) below. For example, each sample shall be listed for each category, i.e., deck, each kind of material (felt gasket, pipe hanger, oil based paint, etc.), and each area such as high voltage electrical equipment areas.

c. Sampling Plan

This sampling plan is a variation of a stratified random sample. In this kind of sampling, the entire population of non-liquid PCBs is divided up into mutually exclusive sub-populations called strata (singular for strata is stratum). Each stratum is sampled independently and is represented independently. In this sample, the weight for the different strata in the total

sample is not equal, but is weighted toward the increased probability, based on historical chemical analysis of PCB for PCBs on vessels, of finding larger amounts of PCBs in certain uses. Samples are taken in each stratum according to a random sampling procedure.

In the event that the representative sample of a stratum finds one sample ≥ 50 ppm, the entire stratum must be resampled following further removal of non-liquid PCBs containing ≥ 50 ppm. Removal of only the sampled material is not acceptable. Resampling requires regeneration of a new random sampling of the stratum to determine whether all materials containing ≥ 50 PCBs have been removed.

For example, assume that the sample of 25 electrical cables, selected in accordance with this policy, showed one cable having ≥ 50 ppm PCBs in one of its non-liquid components. Based on this sample all electrical cable would be considered regulated for disposal. It would not be in compliance with this policy to dispose of the one cable, replace the cable in the sample with another cable which did not have a non-liquid component ≥ 50 ppm and assume that all electrical cable was < 50 ppm and unregulated for disposal. Rather, a new 25 electrical cable sample would have to be reselected in accordance with the policy and reanalyzed. It would be prudent to remove all cable of any type found to contain PCBs ≥ 50 ppm before resampling.

(i) Numbers of samples to be taken

All samples shall be taken and analyzed from the materials remaining on the vessel in uses listed above in V.(a) "Known Sources of Non-Liquid PCBs." There are several different categories of quotas each requiring a minimum number of samples: minimum total from the vessel, minimum total from each deck, minimum total from each kind of use, and minimum total from each of three classes of use (strata). Scrappers may sample more than the minimum number of samples in any or all categories.

(ii) Minimum numbers of samples:

(A) Minimum Total Number of Samples (T) - is the larger of fifteen samples or the square root, rounded off to the nearest whole number, of the gross weight of the vessel as sold in long tons (2,200 pounds equals one long ton);

(B) The minimum total number of samples shall be distributed as follows:

(1) When T is 15

(a) Samples shall be taken according to the following priority order until fifteen samples have been collected. If there are no uses in the category, proceed to the next category.

(i) Four air handling system gaskets.

(ii) Three samples of electrical cable containing of non conducting, non-metal material. Each cable may have several different non-metal components which have to be analyzed individually.

(iii) One sample each from the following category:

(A) rubber gaskets (other than air handling system gaskets)

(B) felt gaskets (other than air handling system gaskets)

(C) fiberglass, felt, foam, or cork thermal insulation material

(D) sound deadening felt

(E) grouting, caulking, rubber isolation mounts, foundation mounts, and adhesives

(F) tapes

(G) pipe hangers, and

(H)- rubber/plastic parts of all sizes and shapes
(other than listed above in VI.c.(ii)(B)(1)(a))

(b) If there are insufficient uses to select fifteen total samples using the procedures in VI. c. (ii)(B)(1)(a), provide in the original notification (required in III. above) to the EPA Regional PCB Coordinator with a reduced scale deck plan of the ship and a written certification that this procedure if followed would result in fewer than fifteen samples.

(2) When T is >15

(a) Minimum Total Number of Samples on Each Deck ("deck quota") - three samples from each level/deck on the vessel, where known sources of non-liquid PCB uses are located prior to any removal activity;

(b) Minimum Total Number of Samples from Each Known Use of Non-Liquid PCBs - a minimum of one sample from each of the known uses of non-liquid PCBs in V.(a) which are present on the vessel .

(c) A further categorization of samples is required as follows. The population of all known sources of non-liquid PCBs in V.(a) will fall into one of these three subpopulations which will be referred to as strata. The strata are: Stratum 1- electrical cable insulation, Stratum 2 - air handling system gaskets, and Stratum 3 - the other known sources of non-liquid PCBs as listed in V.(a), [excluding the known sources of non-liquid PCBs which compose the Stratum 1 and Stratum 2.]

13

(i) Stratum 1- At least 0.4(T) electrical cable samples shall be taken. Each non-conducting materials (plastic, rubber, etc.) from each electrical cable shall be chemically analyzed separately. Three fourths of the total electrical cable samples or 0.3(T) samples shall be taken from electrical cable in engine compartments, auxiliary machinery compartments, areas having radio transmission and receiving equipment, x-ray equipment, radar equipment, and any other high voltage electrical equipment.

(ii) Stratum 2 - At least 0.4(T) samples shall be taken from gaskets in air handling systems. One half of the air handling system samples or at least 0.2(T) samples shall be from air handling systems gaskets engine compartments, auxiliary machinery compartments, and in areas where there fuel, explosives and munitions were stored and handled.

(iii) Stratum 3 - At least 0.2(T) samples shall be taken from this stratum. In the event that $0.2(T) \geq 9$, one sample shall be taken from each of the following nine groups (substrata): rubber gaskets (other than air handling system gaskets); felt gaskets (other than in air handling system gaskets); thermal insulation material (fiber glass, felt, foam, and cork thermal insulation material); sound deadening felt; grouting/caulking, rubber isolation mounts, foundation mounts, and adhesives; tapes; oil-based paint in containers (paint on surface of the vessel is not included); pipe hangers; and rubber and/or plastic parts of all sizes/shapes (other than listed in stratum 1, stratum 2, or the preceding substrata in this stratum). In the event that there is an insufficient number of samples or $0.2(T) < 9$, the 0.2(T) samples shall be randomly selected from a numbered list of the nine substrata.

(d) Samples in different strata may be also be counted in the total number of samples for a deck in VI.c.(ii)(B)(2)(a), so long as all minimum total numbers of samples are taken for each stratum and each "deck quota". For example if the radar compartment is in one of the island decks and two Stratum 1 samples are taken there, no additional samples are necessary to fill the "deck quota." However, additional samples may be taken from that deck to complete required numbers of samples for strata other than deck strata.

(C) Minimum Sample Number Example

Assume that the vessel to be sampled is a 30,000 ton aircraft carrier having six decks in the main body of the vessel and five decks in the island.

(1) *According to VI.c.(ii)(A) the minimum total number of samples is the square root of thirty thousand or 173.2 rounded off to 173.*

(2) *According to VI.c.(ii)(B)(2)(c), 69 samples of cable, 69 samples of air handling systems gaskets and 35 samples of other known non-liquid uses of PCBs are required.*

(3) *Of the 69 samples for cable in Stratum 1, 52 are required to be from specified areas.*

(4) *Of the 69 samples for air handling system gaskets in Stratum 2, 34 are required to be from specified areas.*

(5) *Of the 35 samples taken for known non-liquid PCB sources other than electrical cable and air handling system gaskets (Stratum 3), at least one sample shall be from each of the nine substrata in stratum 3.*

(iii) Removal of Known Sources of PCBs Resulting in Non-Existing Strata

In the event that all of the known uses of PCBs (as listed in IV.(a) and V.(a)) or in a particular stratum or category have been removed from the vessel for purposes of PCB disposal, no samples are required to be taken from that stratum or category to demonstrate that all PCBs ≥ 50 ppm have been removed. The minimum number of samples from the unsampled stratum (or strata) do not have to be transferred to another stratum. The total number of samples, T , is simply reduced by the total number of sampled from each stratum which was not sampled, because all of a known use, which made up a stratum had been removed from the vessel for PCB disposal.

(iv) Selecting Locations for Sampling

Sample locations are to be selected employing floor (deck) plans, a random number table or generator, and a tape measure. Sample locations on each deck (or level) of a vessel are to be selected separately.

(A) Stage 1 - Selection of a Room (Space or Compartment). On each deck, sample sites for each stratum may be selected by three methods for the first stage, which is the selection of a room. Sample locations are taken using the Stage 2 and Stage 3 sampling procedures (in (A) and (B), respectively, below.

(1) Method 1 - In the event that there is only one room on a deck or one room in a stratum, the room is automatically selected.

(2) Method 2 - Rooms (spaces or compartments), including sections of hallways and stairwells on each deck, are assigned sequential numbers and specific rooms (spaces or compartments) are selected using the random number table or generator.

(3) Method 3 - Two dimensional coordinates are to be randomly selected on each deck based on a scale drawing of the deck (floor) plan. Location of selected coordinates is somewhat facilitated by the bow to stern markings all over a vessel. Starboard to port dimensions may be determined by using the floor plan and measuring from

interior bulkheads (walls) rather from the side of the vessel.

(B) Stage 2 - Once a space or compartment is selected, each wall and the ceiling is assigned a number and a wall/ceiling is selected using a random number table or generator.

If there is only one room on a deck or only one room in a stratum the flexibility in Stage 2 and Stage 3 is restricted. In either of these two cases, Stage 2 and Stage 3 are as follows: prepare a numbered list (make a census of) all applicable known locations of sources of non-liquid PCBs (see V.(a)) in the lone room/stratum; select the number, which corresponds to a sample locations in the numbered list, using a random number generator; and collect the sample(s) from the selected locations.

(C) Stage 3 - Location of a sample site on the selected wall (bulkhead) or ceiling (overhead) will be purposive (or intentional) with three conditions.

(1) all quotas must be met for all strata,

(2) if more than one size of cable is present, all cable in the area selected shall be assigned a unique number and one cable selected for sampling using random number table or generator, and

(3) only one sample each of any specific kind of known use of non-liquid PCBs may be collected from a single room (space or compartment), unless the number of rooms (spaces or compartments) having the specific kind of use is smaller than the total number of samples required.

Whichever known source of non-liquid PCBs requires a sample and is found in the room, shall to be sampled from the selected wall or ceiling . If no such known source of non-liquid PCBs is present, another wall or ceiling shall be randomly selected using the procedures in stage 2 and stage 3. Resampling of a wall or ceiling when there is no known source of non-liquid PCBs present shall occur no more than twice (a total of three selections including the original selection) before it is necessary to select another room through stage 1.

(D) Guidance to Facilitate Sample Site Selection

First, locate the specified cable and specified air handling system gaskets sample sites and collect samples. Likely cable (Stratum 1) will be more prevalent on a limited number of decks. Likewise, gaskets (Stratum 2) will be more prevalent on a limited number of decks. Samples from these two strata will likely fill the "deck quota" from (2) above. It may be that the Stratum 1 and Stratum 2 samples will also have to be used to fill other "deck quota" even though these materials may be less prevalent than on the other decks, they may be more prevalent than the scarcer Stratum 3 materials. Note well: Because of the limited prevalence and wide distribution of the varying known non-liquid uses of PCBs on board the vessel, it is prudent to attempt to fill "deck quotas" with cable first and then with air handling system gaskets.

To fill Stratum 3 - "known uses of non-liquid PCBs," it may be more productive to not pre-determine what use would be sampled at a random location, but to search for any/all of the uses and keep a tally of the use strata as they are filled by the random sampling. Assume that the lower decks on a vessel have a higher proportion of thermal insulating material but a lower proportion of electrical cable. Even if all deck strata had been filled on the lower decks it would be prudent to use the random sampling scheme to find thermal insulating material for Stratum 3 even though the "deck quota" might already have been filled. Either a formal or informal comprehensive or cursory census of known uses of non-liquid PCBs on board the vessel. Appendix 2 is an example, will probably speed up sample site selection.

It might also prove prudent to have several alternate randomly selected sites available when sampling to account for the possibility of an ineligible site (a site where no known uses of non-liquid PCBs are found at a randomly selected site). The sampling scheme does not provide for or tolerate the purposive (or intentional) selection of a "nearby" or other convenient sample in the event that a randomly selected site is ineligible.

d. Resampling after Additional Removal of ≥ 50 ppm PCBs

In the event that any individual sample shows greater than 50 parts per million PCBs, further removal shall occur and the entire sample category shall be reselected. It is unacceptable to remove a material showing ≥ 50 ppm and then assuming that there are no other PCBs present at ≥ 50 ppm in the category. In a representative sample, one "hit" of ≥ 50 ppm requires either removal of all of the items on the vessel or resampling of the entire population represented by the sample.

VII. Disposal of Removed PCBs

Once sampled and characterized as to PCB concentration, in accordance with the requirements of 40 CFR 761, PCBs and PCB Items shall be contained and marked for storage and/or manifested for transportation to approved storage/disposal facilities for disposal.

In place of sampling, all non-liquid PCBs removed from a vessel may be assumed to contain greater than 50 ppm PCBs and then must be disposed of in accordance with 40 CFR 761.

Appendix 1

Determination of the PCB Concentration in Non-Liquid PCB Uses for Purposes of Disposal

The PCB regulations do not address the determination of PCB concentrations based on an extraction which simulates environmental exposure. The ultimate fate of many of the non-liquid PCBs is thermal destruction in metal smelting at a smelter meeting the definition at 40 CFR 261.10. For purposes of thermal destruction all PCBs are considered to be accessible to and involved in the destruction process. Risk from thermal destruction should be approached from a total PCB concentration. Therefore, for PCBs to be disposed of by thermal destruction methods, an exhaustive method shall be used to extract the PCBs which are often tightly bound in a plastic, rubber, or resinous matrix. Extraction of PCBs from non-liquid uses shall require toluene as a solvent in a soxhlet extraction method equivalent to Method 3540 in SW-846 "OSW Test Methods for Evaluating Solid Waste." The extract shall be cleaned with concentrated sulfuric acid. Extracts shall be blown down with nitrogen or evaporated in a rotary evaporator. since using a Kuderna-Danish apparatus to concentrate toluene has been found to be problematic, this apparatus is not recommended for use. Chemical analysis shall be according to Method 8080, Method 8081, or Method 8280 or equivalent also in SW-846 "OSW Test Methods for Evaluating Solid Waste."

EPA may consider other proposed extraction and/or chemical analysis procedures so long as, at a minimum, the proposals are submitted to EPA no less than 90 days prior to the intended use of the methods and the following information is also included with the proposal.

- (1) A detailed description of the proposed method. Details should be on the order of the details in Method 3540 and Method 8080, Method 8081, and Method 8280.

(2) Analytical results from at least ten representative samples, having PCB concentrations above and below the concentration of concern, using both the proposed method and Method 3540 with Method 8080/8081/8280 are submitted and the performance of the proposed method indicates equivalence (or improvement) in precision, accuracy, sensitivity, and specificity.

If EPA accepts the proposal, the acceptance and any conditions of acceptance will be in forwarded to the proposer in writing within the 90 days of the receipt of a complete proposal. EPA reserves the right to conduct its own formal verification of the proposed method before issuing an approval. If EPA chooses to verify the method, EPA will notify the proposer in writing no more than 30 days after receipt of the proposal. The notification will indicate the time needed for verification which will be a minimum of ninety days.

Appendix 2 - EXAMPLE OF NON-LIQUID PCB CENSUS ON ONE DECK OF A SHIP

| HANGER DECK | Room Identification Numbers | | | | | | | | | | | | | | | | | | |
|--|-----------------------------|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| <u>NON-LIQUID PCB USE</u> | | | | | | | | | | | | | | | | | | | |
| Electrical Cable | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| Electrical Cable Substratum | x | | | | | x | | | x | | | x | | | | | | | x |
| Gaskets | x | x | x | x | | | | | x | x | x | x | | x | | x | x | x | |
| Gaskets Substratum | | x | x | | | | | | | | x | x | | | | x | | | |
| Rubber Gaskets | | | | | x | | x | x | x | | x | | x | | | | | | |
| Felt Gaskets | | | | | x | | | x | x | | | | x | | | x | | | |
| Thermal Insulation Material (including fibrous glass, felt, foam, and cork), | x | x | | x | x | | | | | | | | | x | x | | | x | |
| Sound Deadening Felt, | | | | | | | | | | | | | | | | | | | |
| Grouting/Caulking Adhesives | | x | x | x | x | | | | x | x | | | x | x | | | x | x | x |
| Tapes | | | | | | | | | | | | | | | | | | | |
| Rubber Isolation Mounts | x | | | x | | | | x | x | | | x | | | | | x | x | |
| Foundation Mounts | | x | | | | | x | | | | | | | x | | | | | |
| Pipe Hangers | | | | | | | | | | x | x | | | x | | | | x | x |
| Rubber/Plastic Parts of Differing Sizes/Shapes | | x | | x | | | | x | x | | | | | | x | x | | | |



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

AUG 5 1996

OFFICE OF
ENFORCEMENT AND
COMPLIANCE ASSURANCE

Mr. James E. Caponiti
Associate Administrator for National Security
U.S. Department of Transportation
Maritime Administration
400 Seventh Street, S.W.
Washington D.C. 20590

Dear Mr. Caponiti:

I am responding to your letter of July 25, in which you request an extension of all the terms and conditions of the enforcement discretion letter for ship scrapping dated November 30, 1995 as modified by the June 6, 1996 paint sampling guidance. The extension you propose would increase to twelve the number of vessels covered in the agreement. All vessels are located at the James River Reserve Fleet in Fort Eustis, Virginia. While it is anticipated that the PCBs will be removed in EPA Regions 3, 4 and 6, since the bidders and the actual PCB removal/scrapping sites are not known at this time, EPA recognizes that these additional ten vessels may be scrapped in EPA regions other than 3, 4, and 6.

The requested extension is approved. Please update Enclosure 1 from the November 30, 1995 letter as soon as you have the information. Please have your staff send a copy of the updated Enclosure 1 to the EPA contacts listed on page 7 of the November 30 letter. Feel free to have your staff contact Diane Lynne from my Office at 202-564-2587 if you have any additional questions.

Sincerely,

Craig E. Hooks
Acting Director
Federal Facilities Enforcement Office



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NWMAR117866

**COMPLIANCE WITH THE TSCA PCB DISPOSAL REGULATIONS:
SAMPLING AND ANALYZING PAINT ON METAL SURFACES
OF VESSELS BEING SCRAPPED FOR METAL RECOVERY**

Sample Size and Weight

Each sample (or subsample in a composite sample) shall be scraped from an area of at least 30 centimeters (30 cm.) by 30 cm. including all paint from the outer surface to bare metal. If the 30 cm. by 30 cm. does not weigh at least 50 grams, additional paint shall be scraped adjacent to the 30 cm. 30 cm. area until at least 50 grams of paint is in the sample.

Number of Samples to Be Collected and Analyzed

The number of chemical analyses exclusive of quality control samples (blanks, duplicates, standards, and spiked field samples) appears in parentheses in the next section. The number of chemical analysis is at a minimum eight plus the potential of one additional sample from each deck.

Location of Sample Collection Sites and Procedures for Compositing Samples

1. One sample from each side of the vessel at any location above the waterline¹ (2)
2. One sample from each side of the vessel at any location below the waterline¹ (2)
3. One sample from the outside of all decks above the main deck (1)
4. One sample from the top of main deck (1)
5. Samples from each deck below and above the main deck as follows:
 - a. One sample composited from three subsamples: a wall, the deck and the bulkhead of the hallways/corridors.
 - b. One composite sample from the deck, the bulkhead, and each wall of one room which is in a living quarters, office space, or other "white collar" area.
 - c. One composite sample from one subsample from each room on the deck

¹The two locations of samples with respect to waterline is to address the possibility of the use of different kinds of paint below the water line. The below the waterline sample does not necessarily have to be under water, only in the area where the paint differs. Often there are even two different colors of paint for these two locations.

which has been used to store ammunition, fuel, or other explosive or flammable material, including but not limited to engine rooms, rooms containing hydraulic equipment and rooms containing heat transfer equipment.

6. Composite into one sample all of the samples from each deck taken in 5.a. (above) (1)
7. Composite into one sample all of the samples from each deck taken in 5.b. (above) (1)
8. Analyze the composite sample from each deck taken according to 5.c. individually. (*)

* the number of decks on the ship

Sample Preparation Prior to Extraction

The paint shall be pulverized or otherwise homogenized.

Extraction , Cleaning and Analysis of the Samples

Extraction cleanup and instrumental analysis shall be according to the methods in SW-846, Test Methods for Evaluating Solid Waste, as specified below.

Sample Extraction

A minimum of 50 grams of paint for each sample or composite sample to be extracted. The extraction solvent shall be toluene and extraction shall be according to Method 3540B or 3541. Once the extraction is complete, toluene may be solvent exchanged into a solvent appropriate for cleaning and instrumental analysis.

Cleaning the Extract

The extract shall be cleaned using Method 3665 followed by 3620A.

Instrumental Analysis of the Cleaned Extract

The cleaned extract shall be analyzed according to Method 8080A or 8081.

Quantitation Limits for the Instrumental Analysis

Quantitation limits for total PCBs shall be less than or equal to 5 micrograms PCBs per gram of paint. If quantitation limits are greater than 5 micrograms PCBs per gram of paint, the extract shall be further cleaned according to Method 3665 and 3630.

Regulated PCBs

If PCBs are found in any of the samples or composite samples at concentrations greater than or equal to 50 ppm, these PCBs are regulated for disposal and prohibited from export.

Linda,

I am very concerned about the chemical extraction procedures (Methods 3550 and 3580) used to Gascoyne Laboratories to analyze the paint. Unless a laboratory is familiar with PCBs in these materials the tendency is to use the quicker/cheaper extraction procedures which are more applicable to soils. Until someone provides OPPTS with data showing that cheaper and quicker extraction techniques (Methods 3550 and 3580) are equivalent to method 3540B and 3541, OPPTS will require the more exhaustive extraction methods for the analysis of paint and plastic/rubber materials containing PCBs. Admittedly, these analytical procedures (3540B and 3541) take longer and may be more expensive, they more clearly reveal the true PCB content in these matrices. EPA enforcement used the more exhaustive extraction methods in analyzing samples taken from the ex-Cabot/Dedalo.

John



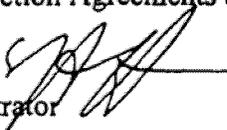
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OCT 24 1997

OFFICE OF
ENFORCEMENT AND
COMPLIANCE ASSURANCE

MEMORANDUM

SUBJECT: Continuance of OPPTS Role in Development, Review, and Concurrence of Enforcement Discretion Agreements and Letters

FROM: Steven A. Herman 
Assistant Administrator

TO: Lynn R. Goldman, M.D.
Assistant Administrator
For Prevention, Pesticides, and Toxic Substances

I wanted to drop you this note to be sure we are coordinated in the development, review, and concurrence of enforcement discretion agreements and letters addressing unauthorized use of PCBs and their distribution in commerce, export of PCBs, and disposal of PCBs.

We continue to contemplate appropriate acts of enforcement discretion, counting on OPPTS to assist in the development, review, and concurrence of technical provisions included in these documents. Before I authorize any OECA official to sign any acts of enforcement discretion concerning these PCB issues, I am requesting a written concurrence by OPPT staff on all future agreements, similar to what we've done in the past.

Would you please send me a note back confirming this plan to stay coordinated?



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

NOV - 4 1997

MEMORANDUM

OFFICE OF
PREVENTION, PESTICIDES AND
TOXIC SUBSTANCES

SUBJECT: OPPTS Role in the Development of Enforcement Discretion Actions

FROM: Lynn R. Goldman, M.D.
Assistant Administrator

A handwritten signature in black ink that reads "Lynn R. Goldman".

TO: Steven A. Herman
Assistant Administrator
Office of Enforcement and Compliance Assurance

Thank you for your memorandum dated October 24, 1997, in which you ask that OPPT remain committed to assisting OECA in the development of, and providing concurrence on, PCB-related enforcement discretion agreements and letters. Of most immediate concern to OECA are the pending agreements addressing PCB use and distribution in commerce, and export for disposal.

We agree that continued OECA-OPPTS coordination in the development of PCB-related enforcement discretion actions is proper. OPPTS (or OPPT) will remain involved in the review of, and will provide written concurrence on (where appropriate), acts of enforcement discretion concerning PCB issues. Additionally, in cases where technical and/or policy assistance is needed in the development of the actions, OPPTS will contribute.

However, to facilitate OPPT review of the subject material, it will be expected that OECA maximize the use of materials/language previously approved where possible, and redline or otherwise highlight those provisions which vary from similar, previously issued and OPPT-concurred-upon actions. Using "boilerplate" and highlighting new language should minimize OPPT's review time of materials (or sections of materials) previously approved.

These commitments are made with the understanding that the timeliness of OPPTS' input may on occasion be impacted by resource availability and Agency priorities.

I hope this adequately responds to your request. If you have any questions, please do not hesitate to contact me.



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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

MAR 03 1995

OFFICE OF
ENFORCEMENT AND
COMPLIANCE ASSURANCE

MEMORANDUM

SUBJECT: Processing Requests for Use of Enforcement Discretion

FROM: Steven A. Herman
Assistant Administrator

TO: Assistant Administrators
Regional Administrators
General Counsel
Inspector General

In light of the reorganization and consolidation of the Agency's enforcement and compliance assurance resources activities at Headquarters, I believe that it is useful to recirculate the attached memorandum regarding "no action" assurances¹ as a reminder of both this policy and the procedure for handling such requests. The Agency has long adhered to a policy against giving definitive assurances outside the context of a formal enforcement proceeding that the government will not proceed with an enforcement response for a specific individual violation of an environmental protection statute, regulation, or legal requirement. This policy, a necessary and critically important element of the wise exercise of the Agency's enforcement discretion, and which has been a consistent feature of the enforcement program, was formalized in 1984 following Agency-wide review and comment. Please note that OECA is reviewing the applicability of this policy to the CERCLA enforcement program, and will issue additional guidance on this subject.

A "no action" assurance includes, but is not limited to: specific or general requests for the Agency to exercise its enforcement discretion in a particular manner or in a given set of circumstances (i.e., that it will or will not take an enforcement action); the development of policies or other statements purporting to bind the Agency and which relate to or would affect the Agency's enforcement of the Federal environmental laws and regulations; and other similar requests

¹ Courtney M. Price, Assistant Administrator for Enforcement and Compliance Monitoring, Policy Against "No Action" Assurances (Nov. 16, 1984) (copy attached).



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NWMAR117873

for forbearance or action involving enforcement-related activities. The procedure established by this Policy requires that any such written or oral assurances have the advance written concurrence of the Assistant Administrator for Enforcement and Compliance Assurance.

The 1984 reaffirmation of this policy articulated well the dangers of providing "no action" assurances. Such assurances erode the credibility of the enforcement program by creating real or perceived inequities in the Agency's treatment of the regulated community. Given limited Agency resources, this credibility is a vital incentive for the regulated community to comply with existing requirements. In addition, a commitment not to enforce a legal requirement may severely hamper later, necessary enforcement efforts to protect public health and the environment, regardless of whether the action is against the recipient of the assurances or against others who claim to be similarly situated.

Moreover, these principles are their most compelling in the context of rulemakings: good public policy counsels that blanket statements of enforcement discretion are not always a particularly appropriate alternative to the public notice-and-comment rulemaking process. Where the Agency determines that it is appropriate to alter or modify its approach in specific, well-defined circumstances, in my view we must consider carefully whether the objective is best achieved through an open and public process (especially where the underlying requirement was established by rule under the Administrative Procedures Act), or through piecemeal expressions of our enforcement discretion.

We have recognized two general situations in which a no action assurance may be appropriate: where it is expressly provided for by an applicable statute, and in extremely unusual circumstances where an assurance is clearly necessary to serve the public interest and which no other mechanism can address adequately. In light of the profound policy implications of granting no action assurances, the 1984 Policy requires the advance concurrence of the Assistant Administrator for this office. Over the years, this approach has resulted in the reasonably consistent and appropriate exercise of EPA's enforcement discretion, and in a manner which both preserves the integrity of the Agency and meets the legitimate needs served by a mitigated enforcement response.

There may be situations where the general prohibition on no action assurances should not apply under CERCLA (or the Underground Storage Tanks or RCRA corrective action programs). For example, at many Superfund sites there is no violation of law. OECA is evaluating the applicability of no action assurances under CERCLA and RCRA and will issue additional guidance on the subject.

Lastly, an element of the 1984 Policy which I want to highlight is that it does not and should not preclude the Agency from discussing fully and completely the merits of a particular action, policy, or other request to exercise the Agency's enforcement discretion in a particular manner. I welcome a free and frank exchange of ideas on how best to respond to violations, mindful of the Agency's overarching goals, statutory directives, and enforcement and compliance priorities. I do, however, want to ensure that all such requests are handled in a consistent and coordinated manner.

Attachment

cc: OECA Office Directors
Regional Counsels
Regional Program Directors



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

NOV 16 1984

OFFICE OF
ENFORCEMENT AND
COMPLIANCE MONITORING

MEMORANDUM

SUBJECT: Policy Against "No Action" Assurances
FROM: Courtney M. Price *Courtney M. Price*
Assistant Administrator for Enforcement
and Compliance Monitoring
TO: Assistant Administrators
Regional Administrators
General Counsel
Inspector General

This memorandum reaffirms EPA policy against giving definitive assurances (written or oral) outside the context of a formal enforcement proceeding that EPA will not proceed with an enforcement response for a specific individual violation of an environmental protection statute, regulation, or other legal requirement.

"No action" promises may erode the credibility of EPA's enforcement program by creating real or perceived inequities in the Agency's treatment of the regulated community. This credibility is vital as a continuing incentive for regulated parties to comply with environmental protection requirements.

In addition, any commitment not to enforce a legal requirement against a particular regulated party may severely hamper later enforcement efforts against that party, who may claim good-faith reliance on that assurance, or against other parties who claim to be similarly situated.

This policy against definitive no action promises to parties outside the Agency applies in all contexts, including assurances requested:

- ° both prior to and after a violation has been committed;
- ° on the basis that a State or local government is responding to the violation;

NWMAR117876